

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY
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EDITOR
LEON J. MENVILLE, M.D.

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HOWARD P. DOUB, M.D.



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No 1

GASTRIC MUCOSAL RELIEF

A MODIFIED SEDIMENTATION METHOD, USING A COLLOIDALLY SUSPENDED BARIUM SULPHATE¹ A PRELIMINARY REPORT

By ROBERT A. ARENS, M.D., and SIDNEY D. MESIROW, M.D., Roentgenologist and Assistant Roentgenologist, Michael Reese Hospital, Chicago

RECENTLY, in this country, there has been a revival of interest in the demonstration of mucosal patterns in the stomach and duodenum, as an aid in establishing the normal and abnormal in gastric and duodenal diagnosis.

This paper will attempt to demonstrate the possibility of a modification of the sedimentation method, by no means a new idea, but one which represents a slight departure from those used in the past.

HISTORICAL NOTE

As early as 1897, Roux and Balthazard, apparently independently and contemporaneously with Walter Cannon in this country, first used a bismuth opaque meal in demonstrating the motor phenomena of the stomach.

Holzknrecht and his group, in 1898, probably saw fluoroscopically the flow of bismuth opaque meals over the gastric rugæ. In 1906, they used a watery suspension of bismuth subnitrate in the preliminary part of the fluoroscopic study of the stomach (10 grams bismuth subnitrate in 50 grams of water, to which was added a tablespoonful of milk sugar). Palpation of the stomach in the erect posture made

possible the visualization of the mucosal folds. After this procedure and while the stomach still contained the bismuth suspension, they distended the stomach by having the patient ingest an effervescent mixture of from four to five grams tartaric acid and from five to seven grams of sodium bicarbonate. This they followed by the usual opaque meal, four hundred grams of milk gruel with thirty-five grams of bismuth subnitrate.

This examination is detailed because of its resemblance to our own procedure.

With the advent of the Snook x-ray transformer, in 1907, and the distinct improvement in visualization due to "stopping" gastric peristalsis, further impetus was given to gastro-intestinal examinations by these methods.

Cole, in 1909, demonstrated gastric rugæ by using the principle of sedimentation of bismuth subnitrate from a *watery suspension* as a special technic. His first films compare very favorably with the more modern methods of examination.

Akerlund, in 1921, working with Forsell, whose classic monograph in 1913 laid the fundamentals of the anatomy and physiology of the stomach before the profession, applied the method of the "thin layer" to diagnosis of the duodenal bulb

¹ "Rugar" furnished through the courtesy of McKesson & Robbins Company

lesions by exerting external pressure to displace all but a thin layer of opaque medium from the bulb

Since then, innumerable observers have contributed both to the relief and thin layer methods, the majority, however having tended to avoid the principle of sedimentation to demonstrate the rugal pattern

Pribram and Kleiber (1927), Hilpert (1928), and Vallebona (1926) revived the use of barium suspension and air distention. Small amounts of barium suspension were ingested and distributed by manual pressure, then the stomach was distended by air injected through a small tube (Pribram, Kleiber, and Hilpert), or by chemical means (Vallebona)

The Cole Collaborators 1934, whose procedure we largely followed, reviewing previous methods, discussed the distribution of an opaque salt by sedimentation, modifying their original procedure of giving the patient one gram of bismuth subcarbonate in four ounces of water, by giving a larger quantity (eight ounces) of water, so that the opaque salt would settle out on a smoother surface and when, after fifteen or twenty minutes, the water was withdrawn, the stomach, diminishing in volume, caused the mucosal folds to appear. This method, they decided, however, could be applied only in special cases as an adjunctive method rather than a routine procedure

ELABORATION OF METHOD OF MUCOSAL RELIEF

It is important to establish here the fundamental necessity of combining both the fluoroscopic and roentgenographic findings in arriving at a satisfactory diagnosis

Therefore, in planning the drink to be used, it was essential that it be made sufficiently opaque to enable proper fluoroscopic observation, yet not interfere with radiographic demonstration of the mucosal folds. This, it was felt, could not be accomplished by the administration of a single opaque meal, since it was known that a meal sufficiently opaque to be visu-

alized fluoroscopically was not sufficiently thin to allow the suspended barium to settle out on the mucosal folds satisfactorily

At first, using a dilution of barium and skimmed milk in proportion of one-to-four, we found that the barium stayed in the stomach too long. With further dilution, up to one-to-thirty, the same objection arose, along with the fact that the barium "caked" rather than separated out in a thin layer over the mucosa

In the attempt to correct these faults, and because it was felt that the skimmed milk contained sufficient fatty material to delay gastric motility, and also had the property of keeping the barium in suspension too long, we turned to diluting with water. This, we found, was immediately but only partially successful, the dilution of apparent maximum efficiency lying between one-to-ten and one-to-fifteen

Since we still had trouble because the barium settled out in clumps, rather than in a finely divided precipitate, we were prevailed upon to experiment with "Rugar," a colloiddally suspended barium sulphate which is freely miscible with milk or water

This, we found on dilution with *water*, *not milk*, to one-to-fifteen strength, was ideal for the purpose intended. The meal, about sixteen ounces, was given to the patient, and after he had lain alternately on his right and left side for only fifteen minutes, films could be taken, the greater proportion of which were successful in demonstrating the gastric pattern, since during that time the barium had settled out and most of the fluid had been evacuated from the stomach. It was then felt that we could further improve the visualization by the introduction of gas or air into the stomach, in direct similarity to double contrast in pneumocolon

Use of the Rehfuß and Levin tubes, followed by air inflation, was not satisfactory. Because of the discomfort to the patient, and because in out-patients the method entailed too much difficulty, we turned to gas distention by allowing the

patient to ingest Seidlitz powders, drinking each powder separately to insure maximum gas formation. The action of the tartaric acid and sodium bicarbonate in production of carbon dioxide gas is well known, and had been used as early as 1906 by Holzknecht and his school, if not earlier.

The results were eminently successful, with the following relatively unimportant exception. It was found that with too much distention, most of the rugal folds were 'ironed' out, a finding which we expected, from the experience of the Cole Collaborators. Distention of the stomach and duodenum has the disadvantage of diminishing the prominence of the mucosal relief.

In connection with Akerlund's thin layer method for the duodenal bulb we felt that attempts at gastric compression would fail, since in the average patient it was frequently impossible to palpate the fundus because it lay so high behind the costal arch.

Because it was felt that it was essential to observe the stomach fluoroscopically, the patient was given a regular meal and the stomach manipulated and palpated following which films were again taken, in order to check completely the findings of the first method.

SOURCE AND AMOUNT OF MATERIAL

A series of gastro-intestinal patients numbering 30 unselected cases were then examined, employing the method. By far the greater number were normals, insofar as the stomach was concerned, allowing the development of familiarity with the average normal pattern. There were however, several which both demonstrated the efficacy of the method and suggested the possibilities of its application.

Of the abnormal, one proved to be an enormous polypous adenocarcinoma of the cardia of the stomach, very well demonstrated by the "combined method" ("Rugar"/water^{1/15} with Seidlitz powder) —see Case 6.

Another revealed the presence of one gastric ulcer, beside the one discovered in

the duodenum, whereas the usual meal had revealed only the duodenal lesion.

Still two others graphically outlined enormous gastric ulcers with the surrounding edema and disturbance in the rugae about the crater.

TECHNIC

The patient was brought to the department without breakfast, stomach empty. The meal (sixteen ounces containing

'Rugar' the colloidally suspended barium, and water in proportion of one-to-fifteen) was given the patient while under fluoroscopic control (in some cases the meal was of sufficient density to permit visualization).

The patient was then placed in the prone position and told to lie first on the left side, then on the abdomen, and then on the right side, dividing the fifteen minutes equally. The patient then took each of a pair of Seidlitz powders and was asked not to belch. Films of the stomach were then immediately taken, in the right lateral, right oblique, and anterior positions. The patient was then given the routine barium meal to enable visualization roentgenoscopically and allow roentgenographic check-up. Films were then taken again.

The following are case reports of the typically normal cases and those which were unusual from the standpoint of pathology.

NORMAL CASES

Case 1. K. J., white female 32 years of age, complained of epigastric pain, headache and vomiting for six months. Physical laboratory and roentgen examinations were negative for abnormalities (See Figs 1-A and 1-B).

Comment. Instead of the usual vertical rugal markings, it is noted here that the markings are scalloped and irregular, suggesting larger rugal folds irregularly distributed on the greater curvature. This examination was done without gas distention. It is highly likely that, while the roentgen examination was deemed negative, the demonstration of these heavy



Fig 1 A

Fig 1 B

Figs 1 A and 1 B Case 1 Scalloped markings in cardia and fundus suggest rugal hypertrophy



rugæ may be significant of a hypertrophic gastritis

Case 2 S J, colored female, 50 years of age, complained of a weight loss of 20 pounds in four years, epigastric pain and somnolence for two or three weeks, and nocturia for two months

Physical examination revealed hypertension (208/94), tenderness in the epigastric gall-bladder area, with a questionable mass which was thought to be gall bladder

Roentgen examination was negative except for a pathologic appendix (Fig 2)

Comment With less evacuation of sedimentation meal, the gross vertical rugal folds are shown. Here one can be absolutely sure that there is no lesion in the antrum or distal fundus

Case 3 White female, 23 years of age, had complained of epigastric pain for two months. She had been a known diabetic

Fig 2 Case 2 Antrum and distal fundus certainly negative



Fig 3 A
Figs 3 A and 3 B Case 3 Gross rugal markings are well shown

for seven years and the diabetes was controlled by insulin

Physical and laboratory examinations were negative except for blood sugar of 325 mgm per c c Roentgen examination was negative (Figs 3-A and 3-B)

Comment Similar to Case 2, vertical rugæ of cardia and fundus well shown

Case 4 N W, female child, 12 years of age, complained of epigastric pain of two months' duration

Physical findings were negative for abnormalities Laboratory findings were within normal range

Roentgen findings Questionable duodenal defect (Figs 4-A, 4-B, 4-C, and 4-D)

Comment The films were taken in the anterior and right oblique positions in both methods The cardia and fundus are extremely well shown Barium sedimentation is even and uniform throughout—definite assurance that this portion of the stomach is negative

PATHOLOGIC CASES

Case 5 H L, white male, 73 years of age, complained of marked anorexia, weight loss of 15 pounds in one year, precordial pain, and loss of appetite due to epigastric fullness

Physical findings revealed only a senile loss of tissue turgor, pulmonary emphysema, and cardiac enlargement

Laboratory examination was negative except for a lack of free acid in the gastric analysis There was no blood in the gastric contents

Roentgen examination revealed an enormous polypous gastric malignancy in the cardia, revealing several polypous filling defects and extending down the lesser curvature and posterior wall to the incisura angularis

Comment The "double contrast" method beautifully demonstrates the extent and nature of the lesion, two large polypous extensions of the lesions on the posterior wall and lesser curvature, and a

smaller polypous extension from the outer superior quadrant of the cardia (See Figs 5-A and 5-B)

a free acid of 40 per cent, a total acid of 75 per cent. No blood in vomitus, gastric analysis, or stool

Fig 4 A

Fig 4 B



Fig 4 C

Fig 4 D

Figs 4 A 4 B 4 C, 4 D Case 4
tionably negative for abnormalities

The fundus and cardia are well shown and unques

Case 6 A B, white male, 60 years of age, complained of intermittent sharp epigastric pains with vomiting two hours after meals for the past two years. He ate five or six small meals per day to avoid pain.

Physical examination was negative for abnormalities.

Laboratory findings. Blood count revealed an elevated white blood count (13,000-21,600), gastric analysis showed

Roentgen examination revealed a large penetrating ulcer crater on the lesser curvature in its middle third. Gastric retention 30 per cent at twenty-four hours (See Figs 6-A and 6-B).

Surgery. A tremendous ulcer crater was shown on the lesser curvature of the stomach, penetrating into the pancreas, the defect in the stomach about the size of a silver dollar.



Fig 5 A

Fig 5 B

Figs 5 A and 5 B Case 5 Note the clearness with which the combined method shows the intragastric neoplastic protrusion

Pathology Chronic penetrating benign ulcer crater, five centimeters in diameter. There was no evidence of malignancy.

Patient subsequently developed parotitis and peritonitis and died.

Comment The routine method reveals a large penetrating crater on the lesser curvature.

Sedimentation meal reveals the crater with lack of rugal markings in crater proper, but since the retained fluid continually washed the markings away, the findings are not as typical as could have been desired.

Case 7 A F, white female, 54 years of age, complained of a weight loss of 20 pounds in one year, epigastric and lower abdominal pain soon after eating, and vomiting. She gave a previous history of removal of a pseudomucinous papilliferous cystadenoma of the ovary.

Physical examination revealed a large, tender, nodular liver, a nodular mass in the epigastrium not related to the liver, and also one in the right lower quadrant.

Laboratory findings Ewald meal with histamine revealed no free acid, but blood. Because of the former ovarian pathology, the question of a Krukenberg tumor was raised. A review of the microscopic sections failed to reveal any evidence of malignancy.

Röntgen examination revealed a filling defect at the distal end of the stomach fundus, extending into the antral area on the greater curvature side. The walls of the antrum were rigid. Because of the rigidity, the filling defect, and the lack of normal rugæ in this area, it was felt to be a primary gastric malignancy. (See Figs 7-A and 7-B.)

Surgical exploration revealed a large scirrhous carcinoma involving the junction



Fig 6 A



Fig 6 B

Figs 6 A and 6 B Case 6 Because of retention, the mucosal pattern was not constant, but the crater is revealed by both the routine and the sedimentation methods



Fig 7 A



Fig 7 B

Figs 7 A and 7 B Case 7 Note filling defect in distal fundus with loss of rugal pattern which is better shown in Fig 7 A and which proves conclusively that the tumor is intragastric



Fig 8 A



Fig 8 B

Figs 8-A and 8-B Case 8 The fluoroscopic film Figure 8 A reveals the crater with surrounding edema. The sedimentation film reveals in addition to the above a collection of barium within a crater which was overlooked and which represented a second ulcer, found at surgery (Arrow to the right in Figure 8 B)

of the fundus and pyloric antrum, with large liver and omental metastases

Comment Both routine and sedimentation methods revealed the filling defect at the distal end of the fundus, extending into the antrum. Because of the pressure of the spine and the relatively small amount of intragastric material, the filling defect is more accentuated in the latter method. Also, the absence of normal rugae in this area is better shown in the sedimentation film. It was felt, in this case, that the sedimentation method distinctly proved that the lesion was primarily intragastric.

Case 8 A R., white male, 65 years of age, complained of dull aching epigastric pain, with vomiting, one hour after meals, of five months' duration. Physical examination was negative, except for mid-abdominal tenderness.

Laboratory tests revealed a faint trace of blood in the vomitus, and a gastric free acidity of 12.5 per cent. No blood was noted in the stool.

Electrocardiogram "Myocardial damage"

Roentgen examination revealed a plateau-like intragastric filling defect projecting into the lumen on the lesser curvature, extending above and below the incisura angularis, in the summit of which there was a large crater (Fig 8-A).

Surgery revealed the presence of one large benign ulcer on the lesser curvature, with marked surrounding edema, and also another small crater about six centimeters from the above, on the posterior wall, which roentgen examination failed to reveal.

Comment The sedimentation method revealed the first lesion quite clearly,

showing the crater and surrounding edema. Just to the left, on the posterior wall, be-

was paid, but which undoubtedly represented the second lesion (Fig 8-B)



Figs 9 A, 9 B and 9 C Case 9 Routine meal reveals only duodenal ulcer and cholelithiasis whereas the sedimentation film (Fig 9 C) shows the gastric lesion beside the above

tween both curvatures, one notices a faint collection of barium to which no attention

Using the routine method made the demonstration of either lesion difficult and

it was only under fluoroscopic localization that we were able to demonstrate the larger lesion radiographically

Case 9 E P, white female, 63 years old, complained of gnawing epigastrie pain for six weeks and a weight loss of 35 pounds in five or six years. Physical examination revealed diffuse abdominal tenderness, more marked in the right lower quadrant.

Laboratory findings Gross tarry blood in the stools on seven occasions

Röntgen examination revealed both gastric and duodenal ulcers and cholelithiasis (See Figs 9-A, 9-B, and 9-C) No surgery was done

Comment The sedimentation method here showed especially well the gastric crater filled with barium and the disturbance in rugal pattern about it, while the routine examination was doubtful as to the presence of a definite ulcer

DISCUSSION

We are in complete agreement with the Cole Collaborators that the sedimentation method cannot be used as a routine method to the exclusion of the regular barium meal, and hence must be used as an adjunctive examination in special cases, for the reason that the resultant films are not as constant in depicting gastric abnormalities as is the standardized meal

However, since it is difficult to place the patient in such a position as to demonstrate the filling defect or crater in profile, so that the defect or crater can actually be seen, and since the routine meal is sufficiently opaque to obscure visualization in any but the profile position, it is felt that

the sedimentation method could, in a case presenting puzzling features, considerably add to our present armamentarium

For lesions to be demonstrated in the cardia, the sedimentation method with partial gas distention is excellent, outlining tumor masses or abnormalities in the same manner that the pneumocolon reveals lesions in the colon

SUMMARY

A modified sedimentation is described using "Rugar," a colloidal suspended barium, freely miscible with water and milk

A series of 30 gastric examinations is presented, with case reports of the typically normal and several of the unusual abnormal cases

It is hoped that the method outlined will form a basis for further study of the sedimentation method as a means of demonstration of the mucosal relief of the stomach

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THE BIOLOGIC MEASUREMENT OF DEPTH DOSES

By CHARLES PACKARD, PH D., *New York City*

From Columbia University, Institute of Cancer Research, F C WOOD, M D, Director

THE purpose of this article is to show how depth doses can be measured by means of a biologic method, and to indicate the degree of precision which may be obtained. This is illustrated by results of tests on *Drosophila* eggs.

The use of living test objects, such as eggs or seeds, as indicators of dosage is by no means new. As early as 1915, Ritter, Rost, and Kruger (19) employed large numbers of lettuce seedlings in order to compare the relative biologic effectiveness of different Sahouraud doses. Kroung and Friedrich (10) used frog eggs in their experiments to test the action of different x-ray wave lengths. Later, Jungling (9) used peas and beans to determine depth doses. The seedlings were irradiated in a wax chamber held at various levels below the surface of the phantom. The criterion of effect was the relative increase in root length after exposure. These investigators and others who made similar experiments, realized that their results were not wholly satisfactory, but they were convinced of the value of the method. Lorenz and Rajewsky (11) remarked that "since the ultimate aim of measurement is to determine the biologic effect of the rays, a biologic method would appear to be the most logical." They concluded, however, on the basis of experiments already made, that the results were of no great value since they showed only the order of magnitude of the doses which were to be measured.

The unsatisfactory results were due largely to inadequate methods. It is now realized that seeds used in this kind of experiment must be carefully selected for size, and must be in approximately the same stage of germination. After exposure great care must be exercised to prevent injuries to the growing root tip, and to maintain a proper degree of mois-

ture and temperature. With all these precautions, the amount of root growth is still variable. Thus, Henshaw and Francis (6) find in their control material consisting of 17 samples, each containing 25 seeds, that the average root length of the different samples varies to a considerable extent, however, because of the large number of individuals which they used, the amount of variation, from a statistical point of view, is not large. It is evident that if the relative magnitude of surface and depth doses is estimated by the amount of root growth, or by some other biologic reaction, the comparison is between two quantities both of which may be affected by the normal variability of the test objects. Only by using large numbers of specimens can this source of error be eliminated.

In the past few years appropriate biologic methods and accurate physical measurements have produced significant data regarding depth doses. Hussey (8), using *Drosophila* larvae as indicators, found that depth doses in a paraffin phantom are much the same as those obtained with thimble chamber dosimeters. Sugiura (20) irradiated particles of Mouse Sarcoma 180 at various depths in a phantom, and estimated the dose which they received, as compared with the surface dose, by finding the proportion of takes after the particles had been inoculated into healthy animals. The percentage depth doses obtained in this way were not unlike those determined by physical means. Henshaw and Francis (6) have used wheat and lettuce seedlings, determining the surface and depth doses in a paraffin phantom for both 200 kv x-rays and for gamma rays. They observed that for x-rays the depth doses measured by the seedlings were somewhat lower than those indicated by ionization readings.

As test objects for studying depth dosage, the eggs of *Drosophila* possess an advantage over other kinds of material in

to which they belong are not large, the greatest being 6.8 per cent and the smallest, 0.2 per cent. The magnitudes of the

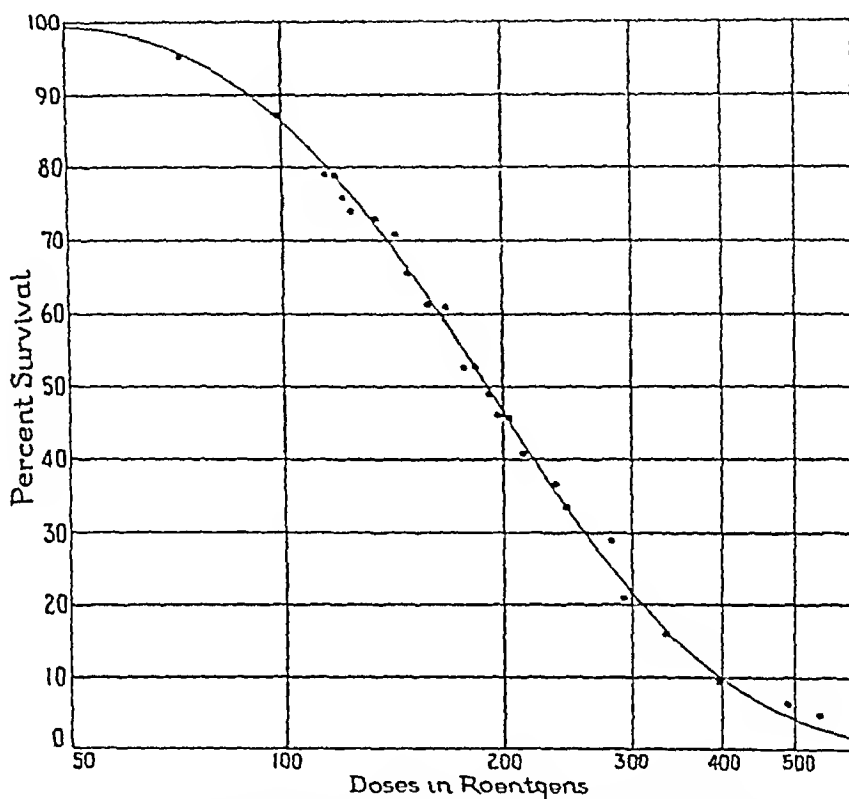


Fig 1 The relation between the percentage of surviving *Drosophila* eggs and the incident dose. The logarithms of the doses are given on the abscissa

that their quantitative reaction to equal doses of radiation remains the same year after year, and the amount of variation between the results of repeated tests is relatively small. To illustrate the constancy in response, and the amount of variation which may be expected in these experiments, the data in Table I are presented. These form a part of a large series of similar tests made during the past six years. The eggs were exposed in air, free from scatter, to doses measured with a calibrated Victoreen dosimeter. In all cases, the voltage was 120 kv, and the filtration, 0.25 mm Cu and 1.0 mm Al. The half value of the beam was 0.33 mm Cu. It will be seen that the differences between the results of individual tests and the average of the series

Probable Error of the Means indicate that these averages do not differ significantly from a theoretically correct average which might be obtained from a very large number of similar tests. Statistical analysis of the entire series of tests, now numbering more than 200, show that the Probable Error of a single observation is ± 2.4 .

The relation between dose and biologic effect, that is, the percentage of surviving eggs in a sample, is best shown by plotting all the data obtained in the manner just described, against the logarithms of the doses. The resulting curve (Fig 1) is a symmetrical ogive. The fact that the amount of effect of injurious agents often increases with the logarithm of the dose rather than directly, was remarked as long ago as 1879 by Galton, and has been

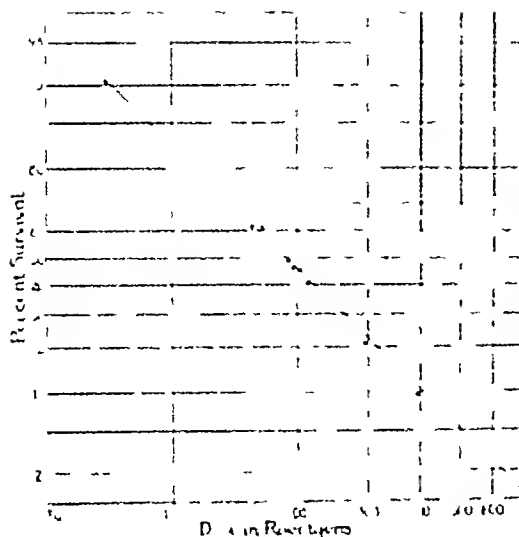


Fig. 2

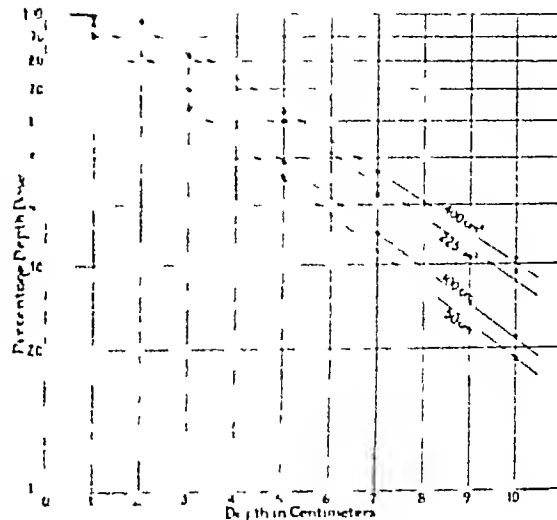


Fig. 3

Fig. 2 The data appearing in Figure 1 are plotted here on logarithmic probability paper

Fig. 3 Percentage depth doses under portals of different arc is The conditions of exposure are 120 kv 0.25 mm Cu and 1.0 mm Al filter 30 cm distance half value layer 0.33 mm Cu

observed more recently in many toxicological studies. The curve is the integrated form of the familiar probability curve and can be changed into a straight line, for statistical purposes, by plotting it on logarithmic probability paper (Fig. 2), or by transforming the data, instead of the paper, into probability units, following the methods devised by Bliss (1), and plotting them on co ordinate paper. The curve now shows how many roentgens must be delivered in order to produce any desired percentage of survivors. The relation between dose and biologic effect is not altered by changes in the wave length of the incident beam. Tests made with voltages ranging from 12 to 550 kv show that when the doses are measured by means of open ionization chambers, equal numbers of roentgens produce equal amounts of reaction. The curve can be used, therefore, without correction for experiments on *Drosophila* eggs when ordinary voltages are employed.

Definite doses result in definite percentages of survivors. The reverse statement is also true, the percentage of survivors is an accurate measure of the dose. This biologic method of measurement,

briefly described elsewhere (12, 13) is illustrated in Table I where, on the lowest line appear the number of roentgens which, as shown by the curve correspond to the average percentage of survival in each series of tests. The agreement between these figures and the actual doses,

TABLE I

Dose	118 r	149 r	202 r	246 r
Percentage of survival	73.9	58.5	41.2	28.8
	75.8	60.3	42.0	28.9
	76.2	63.0	42.1	29.2
	76.9	63.5	42.2	30.9
	78.0	63.6	44.3	31.6
	78.3	65.0	45.0	32.0
	78.2	65.1	45.1	32.2
	79.2	66.0	45.8	33.8
	79.5	66.1	45.9	36.5
	79.8	67.0	46.3	37.2
	80.1	67.2	46.6	38.2
	81.2	67.3	47.0	38.6
Ave	82.4	68.0	47.4	39.2
	85.5	69.1	48.4	
		69.3	48.8	
			49.7	
	78.9	65.3	45.5	33.6
P E m	± 0.52	± 0.52	± 0.41	± 0.64
Biol r	120	151	203	244

To show the degree of variation in results when the same dose is given to different samples of eggs and the number of biologic roentgens corresponding to the average percentage of survival

shown at the top of the table is very close indeed. In these series, the number of separate tests is larger than is needed to obtain a fair average. Not more than ten are necessary when all the experimental conditions are satisfactory.

Because the doses thus measured are estimated by means of this biologic standard and only indirectly from physical measurements, they should be clearly distinguished from the latter. This unit of measurement is called, therefore, the Biological Roentgen (14). Although strictly speaking, the use of such a term is not correct, yet the expression conveys a real meaning and therefore is permissible. Table II illustrates the way in which doses

tween these and the incident doses appear in the fourth column. The average of these ratios is 120.6 per cent. Thus, at 3 cm depth under the conditions stated in the caption, the intensity of radiation is about 21 per cent greater than that of the incident beam. The amount of variation between the separate tests is, in this instance, small. Other depth dose data given below, indicate that in general it is larger than when the tests are made in air, without scatter. This is undoubtedly due to the difficulty of maintaining exactly similar experimental conditions throughout the entire series of depth dose exposures.

EXPERIMENTAL

TABLE II—120 KV, 0.25 MM CU PLUS 1 MM AL, 30 CM DISTANCE, AREA OF PORTAL, 400 SQ CM, DEPTH, 3 CM BELOW THE SURFACE OF THE PHANTOM

Dose	% Surv	Biol r	Ratio
103 r	76.4	125	121.4
103	74.8	120	125.2
119	67.4	147	123.5
120	68.8	143	119.3
122	65.2	152	124.6
129	62.1	160	124.0
141	59.9	165	117.0
144	58.2	169	117.4
147	59.4	166	112.9
147	57.0	171	116.3
149	54.7	178	119.4
152	50.0	190	125.0
172	44.0	207	123.5
176	44.6	205	116.5
183	37.5	229	125.1
185	38.4	226	122.2
218	28.9	263	120.6
Ave			120.6
P E _m			±0.57

To illustrate the method of determining depth doses by the biologic method

are determined in biologic roentgens. In this series, the eggs were submerged to a depth of 3 cm in a water phantom. The incident doses, measured without scatter, result in percentage survivals shown in the second column. In the third column are the doses expressed in biologic roentgens, that is, the number of roentgens shown by the curve to correspond to each percentage of survival. The ratios be-

The arrangement of the apparatus used in these experiments is as follows. The x-ray tube is enclosed in a lead-lined box which effectively stops all stray radiation. A lead glass bowl, having an aperture of 10 cm at the base, surrounds the tube. Below this, 22 cm from the target, is a lead diaphragm with a portal of 15 × 15 cm which is closed by the filter. A sliding lead door below the portal serves to interrupt the beam. The water phantom, 38 × 38 × 30 cm, made of wood, is covered by a lead sheet having a portal of the desired size. This sheet is 1 cm above the surface of the water, which, in all of the experiments, was 30 cm from the target. With this arrangement of diaphragms most of the off-focus radiation, which according to Thoracius (21), may add as much as 25 per cent to the intensity of the direct beam, reaches the surface of the water. The surface dose is thus at a maximum, but a considerable part of the off-focus radiation enters the water at such an angle that it passes to the sides of the phantom and has very little effect on a dosimeter or on eggs placed at a depth of 10 cm (11). The actual depth dose values at this level are, therefore, not much influenced by the arrangement of diaphragms, but the surface doses will vary considerably. Since depth doses are usually expressed as percentages of the surface dose, their per-

centage values will change with diaphragm conditions. Without doubt the wide variation in the surface dose values already published is due in part to this situation.

The eggs to be exposed are placed in a holder consisting of a bakelite sheet $32 \times 13 \times 0.3$ cm in which are cut numerous square holes. One side is sealed by a sheet of cellophane covered with beeswax. In the compartments thus formed are placed slips of filter paper carrying the eggs. The compartments are then sealed with a second sheet of cellophane and beeswax and the holder is inverted, and held at the desired level in the phantom. The eggs, therefore, during exposure, lie on a level with the upper surface of the holder, from which level the depth is measured. The maximum length of exposure was 25 minutes. The doses, measured in air, without scatter, varied from 100 to 600 roentgens. After exposure the eggs on their slips of paper are kept in a moist chamber and counted on the second day following the exposure. In all of the experiments the conditions of exposure were 120 kv, 0.25 mm Cu and 10 mm Al filter, 30 cm distance from the target to the surface of the water, half value, 0.33 mm Cu.

RESULTS

Surface doses, and depth doses at various levels in the central beam, have been

measured under square portals of 400, 225, 100, and 50 sq cm area. The results are summarized in Table III, and shown in graphic form in Figure 3. Each figure in the table is an average of 10 or more tests and is computed by the method illustrated in Table II. The entire series comprises more than 300 experiments. The Probable Errors of the Means indicate the degree of precision of the measurements. By adding to and subtracting from the averages given a quantity equal to three times the Probable Error, the limits between which the true biologic doses lie, may be found. Calculation will show that the values given in the table are correct within 2 or 3 per cent. In the third column of the table appear the percentage depth doses.

The latter figures agree in part with those of Grebe and Nitzge (4) which are given for comparison. Under all portal sizes the surface doses are much the same, under the smaller portals the correspondence is close at all the levels tested. Under the larger portals, the agreement is good at depths greater than 5 cm, but at lesser depths the biologic method registers values which are significantly higher than those obtained by dosimetric means.

The percentage depth doses are plotted in Figure 3, where they are expressed in logarithms. The points tend to fall along straight lines. This exponential relation,

TABLE III—120 KV, 0.25 MM CU PLUS 10 MM AL, HALF VALUE, 0.33 MM CU, DISTANCE 30 CM

400 sq cm				225 sq cm		
Depth	Depth Dose	% D D	Grebe Nitzge	Depth Dose	% D D	Grebe Nitzge
0	140.8 ± 0.72	100	100	133.9 ± 0.87	100	100
1	138.0 ± 0.61	98	96	130.7 ± 1.13	98	96
2	136.2 ± 1.17	97	84			
3	120.6 ± 0.57	86	75	109.4 ± 1.00	82	72
5	87.6 ± 0.81	62	53	80.4 ± 0.59	60	52
7	67.5 ± 1.00	47	45	56.6 ± 0.66	42	39
10	43.4 ± 0.72	31	30	38.9 ± 0.64	29	24
100 sq cm				50 sq cm		
0	130.2 ± 0.68	100	100	119.3 ± 0.70	100	100
1	124.6 ± 0.74	96	94	107.8 ± 1.31	80	89
3	90.9 ± 0.45	70	68	76.4 ± 1.30	64	61
5	63.5 ± 0.80	49	49	54.3 ± 0.89	46	42
7	45.5 ± 1.20	35	35			
10	27.8 ± 0.61	21	21	22.9 ± 0.95	18	18

Depth doses in a water phantom determined by the biologic method

first pointed out by Bolaffio (2), is found in practically all of the depth dose data obtained by investigators using both high and low voltages. The figure shows that under the large portal areas the curves drop slowly from their point of origin and become exponential below a depth of 2 or 3 cm, while under small areas they are exponential below the first centimeter of depth. If, as seems probable, this relationship is of general occurrence, the measurement of depth doses, especially under the smaller portals, is greatly simplified. Two or three determinations will establish the slope of the curve, from which can be read the correct depth doses at any intermediate points.

The biologic method has also been used to determine the distribution of x-ray intensities in the water phantom at points outside of the central axis of the beam. The experimental procedure is the same as before. Several samples of eggs are placed in compartments in the bakelite holder at various distances from the center, and irradiated simultaneously. Table IV gives data from a single experiment to illustrate the method of computing the depth doses at the different points. In this test the eggs were submerged to a depth of 5 cm, the other experimental conditions being given in the caption. In the second column are given the percentages of survival for each position, in the third, the doses in biologic roent-

TABLE IV—120 KV, 0.25 MM CU, 1.0 MM AL, 30 CM DISTANCE, 400 SQ CM PORTAL, 5 CM DEPTH, DOSE 284 r

Distance from Center	% Survival	Biologic	Ratio	% Depth Dose
0 cm	33.8	241	85	61
5	35.8	221	79	56
7	41.5	215	76	54
9	65.6	151	53	38
11.5	79.8	118	42	30

Data from a single experiment to illustrate the method of determining the distribution of x-ray intensity in a water phantom.

gens which the eggs must have received to produce the observed survival rates. In the fourth column are the ratios between the biologic doses and the incident dose, which in this experiment was 284 r. In the fifth column these figures are expressed as percentages of the surface dose which, as shown in Table I, is 141 per cent. It will be seen that the percentage of surviving eggs increases rapidly as the distance of the point of irradiation from the center increases, and that the depth doses decrease correspondingly.

The results of many similar experiments at this and other depths have been averaged, and are shown in Figure 4. A comparison of the course of the isodose curves with those figured by other investigators shows that under these experimental conditions, the intensity of radia-

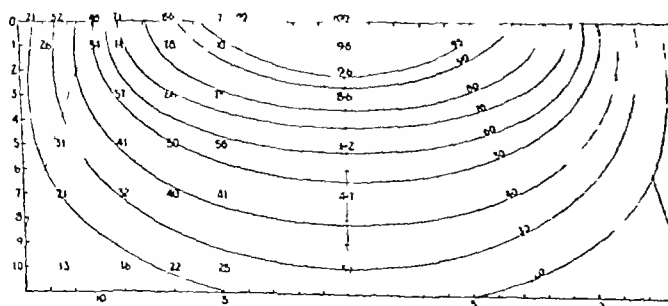


Fig 4

Fig 4. Isodose chart showing the distribution of x-ray intensity in a water phantom. Area of portal, 400 sq cm. Other conditions as in Figure 3.

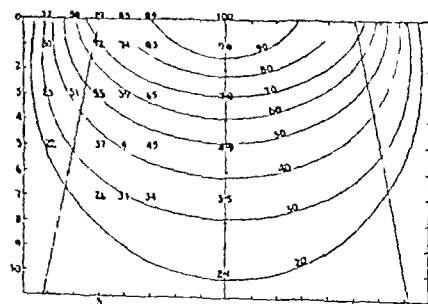


Fig 5

Fig 5. Isodose chart showing the distribution of x-ray intensity in a water phantom. Area of portal, 100 sq cm. Other conditions as in Figure 3.

tion in the first five centimeters below the surface of the phantom is decidedly greater than has previously been reported. The higher depth dose values are found not only in the central beam but also at some distance from it.

Figure 5 shows the results of other experiments made under a portal of 100 sq cm. The values of the depth doses in the central beam are approximately the same as those given by Grebe and Nitzge. The course of the isodose curves does not differ significantly from those based on dosimetric measurements.

The fact that the biologic method of measurement reveals higher intensities near the surface of the water than are shown by dosimeters calls for further examination. The total intensity at any point in the phantom consists of primary and scattered radiation. The amount of the former can be calculated from physical tables or determined directly by dosimetric means. It follows that the lack of agreement between the results of different investigators must be due to differences in the measurement of scattered radiation.

A direct biologic measurement of scattered radiation can be made in a simple way. Two samples of eggs are placed in the bakelite holder and submerged to the desired depth. Over one is held, at a distance of 2 cm, a lead shield just large

enough to cut off all direct radiation. The other sample is not covered. The first can be affected only by scattered rays coming from all parts of the phantom except the small volume of water directly above it, the second receives both direct and scattered rays. The dose that each sample receives, measured in biologic roentgens, is determined from the survival rate of the eggs. In Table V are given the results of several such tests. The ratios between the biologic doses and the incident doses appear in the last column of each section, the average value is given below. The primary intensity at each level shown at the bottom of each section of the table, was determined by dosimeter tests in the following way. The intensity in air of a very narrow beam was first found. Then a container of thin celluloid was placed at some distance above the thimble chamber and filled with water to depths of 1, 3, 5 and more centimeters, and the beam again measured. The sum of the intensity of the primary beam at each level as thus determined and of the scattered radiation, measured biologically, almost exactly equals the total intensity, measured by the latter method. It thus appears that the large depth dose values found under the large portals are not the result of accidental variations, but that they fairly represent the biologic activity of the radiations at those levels.

TABLE V —120 KV, 0.25 MM CU AND 1.0 MM AL FILTER, 30 CM DISTANCE, 225 SQ CM AREA

	With Lead Shield				Not Covered		
	Dose	% Alive	Biol. r	% Incident Dose	% Alive	Biol. r	% Incident Dose
3 cm Depth	236	76.1	138	58.5	30.9	254	107.6
	237	62.6	158	66.7	30.1	257	108.4
	280	60.9	163	56.4	21.0	303	104.9
	280	52.9	183	63.3	18.4	320	110.8
	Intensity of Scattered Radiation				Total Intensity		
	Intensity of Prim. Beam				107.9		
5 cm Depth	175	89.8	94	53.7	68.5	144	82.3
	215	81.4	114	53.0	54.9	178	82.6
	284	78.0	122	42.9	36.8	231	81.0
	295	66.2	149	50.5	33.9	240	81.4
	298	58.8	168	56.4	41.0	217	72.0
	Intensity of Scattered Radiation				Total Intensity		
	Intensity of Prim. Beam				80.0		

The measurement of scattered radiation

DISCUSSION

The value of the biologic method of measurement is sometimes judged by the degree to which its results conform with those obtained by the use of thimble chamber dosimeters the assumption being that the latter are substantially correct.

The problem of the direct measurement of the surface dose may now be regarded as solved," according to Holthusen and Braun (7). But the very considerable differences recently reported between the results of experiments to determine surface and depth dose values indicate that the problem is still unsettled.

There are several reasons for this lack of agreement. One is that there is no standardized method of taking dosimeter readings. The number and position of the diaphragms appreciably affect the apparent magnitude of the surface dose (11, 21), but these details are not often mentioned in the description of the experiments. Whether the different scattering media used, such as water, paraffin of unspecified density, unit density wax, and rice powder, are alike in their absorbing and scattering properties under different experimental conditions has not been satisfactorily determined.

Another factor which influences the magnitude of the surface dose is the size of the thimble chamber. Parker and Honeyburne (16) point out that with chambers of large diameter the recorded doses, particularly near the surface, are also large. At a depth of one centimeter doses in excess of the surface dose may be obtained. Such values are given by Grebe and Nitzge (4) and by Holthusen and Braun (7). But with smaller chambers the intensity at this level is found to be equal to or less than that at the surface, never greater. "The nature of the variation of apparent depth dose with chamber diameter was such that the measurements with the smallest chamber diameter available appeared to be practically identical with the attempted extrapolation to zero chamber size, except possibly for depths less than 2 cm."

These factors affect to an appreciable extent the results of dosimeter measurements but they do not explain the large differences in the magnitude of the recorded surface doses when the conditions of exposure are substantially alike. For example, for a definite area and approximately the same quality of beam, and the same distance, the percentage of scatter at the surface of the phantom is given as 27 (17), 33 (7), 38 (21), and 51 (18). There is thus a difference of 100 per cent between the lowest and highest values. Another lack of agreement occurs in statements regarding the relation between the amount of scatter at the surface and the wave length of the incident beam. Quimby and Marmeli (17) find no change with increasing hardness. The range which they investigated is represented by half values in copper of 0.8 to 2.4 mm. But later Quimby and others (18) observed that the surface scatter decreases decidedly as the hardness of the beam increases. In these tests they used a special type of ionization chamber consisting of parallel threads of silk. Similar relations have been reported by Glocker and Kaupp (3), Gunsett and Nouroutine (5), and recently by Parker (15) whose surface dose values are nearly as high as those reported by Quimby (18).

The absolute values of depth doses, reported in recent literature, also vary considerably, being large when the surface doses are large and *vice versa*. When, therefore, depth doses are expressed in the usual way, that is, in terms of the surface dose, the percentage values found by different investigators are not very different. Thus, all of the actual surface and depth doses reported by Parker (15) are much higher than those given by Grebe and Nitzge (4) and Holthusen and Braun (7), but the percentage depth doses are nearly identical except those relating to depths of one and two centimeters below the surface. This situation indicates that differences in actual dosage values are due to the dosimeters which are used. And this, in turn, again emphasizes the

fact that the methods of thimble chamber dosimetry are still far from perfect.

The results of a biologic method of surface and depth dose measurement will also be affected by some of the experimental conditions just mentioned, such as the number and arrangement of the diaphragms, and the nature of the scattering medium. But a very real advantage of using small living test objects such as *Drosophila* eggs, lies in the fact that the eggs which are biologic dosimeters, approach 'zero size'. And since they lie in a single layer during exposure, they register the actual intensity of the radiation in a plane, rather than the average intensity in a volume of scattering medium, as thimble chambers must necessarily do.

The value of a biologic method of measurement depends to a large degree on the constancy of sensitiveness in the samples of test objects used during the experiment. When the response of these samples to equal doses remains about the same day after day, the measurement will be precise and dependable. The data presented in this paper show that under satisfactory experimental conditions, the results of the *Drosophila* method are correct within ± 3 per cent. When, therefore, they do not agree with those obtained by thimble chamber dosimeters, there is good reason for asserting that the biologic method gives the more correct measurement of the biologic dose.

SUMMARY

1 The response of *Drosophila* eggs to measured doses of x-rays is so constant that it can be used as a measure of dosage. A precision of ± 3 per cent may be expected.

2 The procedure followed in making surface and depth dose determinations is described.

3 Under large portals (225 and 400 sq cm) the intensity of radiation in the first five centimeters below the surface of a water phantom is found to be higher than has heretofore been reported. This is due to the large amount of scattered radiation, which has been measured. At

the surface and at depths greater than 5 cm, the intensities are not significantly different from those given by Grebe and Nitzge. Under smaller portals (50 and 100 sq cm) no unusually high depth dose values were found.

4 The intensity of radiation at points outside the central beam has been determined.

5 The biologic method records more accurately the biologic activity of x-radiation than does the present dosimeter method.

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THE DETERMINATION OF X-RAY QUALITY BY FILTER METHODS¹

By LAURISTON S. FAYLOR, National Bureau of Standards, Washington, D. C.

WITHIN the past decade much has been written and more said about the question of the measurement of x-ray quality. It is not the purpose of this paper to propose any new method, but rather to discuss and compare the several more commonly advocated methods of quality determination from the points of view of their physical soundness and clinical application.

It is important to clarify the two principal viewpoints regarding x-ray quality. To the physicist, x-ray quality means the distribution of energy among the different wave lengths present in an x-ray beam. This distribution is not only difficult to determine, but also when known is of little or no practical value to the radiologist in solving his everyday treatment problems. On the other hand, quality to the radiologist means some descriptive index which will permit reproduction of one of the essential treatment factors, namely, the "penetration" or "depth dose." In outward appearance, these two viewpoints seem widely separated, but it must be obvious that both have a parallel bearing on the problem under consideration in that each characterizes the same property. Since it is the radiological problem that concerns us, we will discuss quality from that viewpoint, and at the same time endeavor to explain its foundation on sound physical concepts.

The spectral energy distribution of x-rays is fixed by the value of the exciting potential at the particular instant in question. Thus, for constant potential excitation, the spectral distribution is the same at all instants, since the tube voltage is not changing with time. For a fluctuating potential, the spectral distribution is changing cyclically and the average or effective distribution over a complete cycle

can be calculated only with difficulty. Its experimental determination is practical only with a crystal spectrometer. However, for the same voltage wave form the average spectral distribution will remain constant.

Hence, the radiologist's "quality" problem would be solved (or rather eliminated) if it could be universally agreed to use the same exciting wave form—an impossible solution for practical reasons. On the other hand, constant excitation voltage is easily producible universally, and hence by its means quality standards may be established and reproduced at will. It is not meant to imply that only constant potential should be used clinically, but to point out a possible (if perhaps undesirable) solution to the problem of measuring x-ray quality. X-ray excitation by pulsating voltages has its practical advantages and will always be present—accompanied by the problem of specifying the radiation quality from the "reproduction" point of view.

It may be well to emphasize at this point that quality specifications which involve a description or approximation of the voltage wave form are akin to lifting oneself by the bootstraps. For as shown in the two preceding paragraphs, quality description is necessitated solely through our inability to utilize a knowledge of wave form even when available. X-ray quality standards have been grouped by some into two classes with respect to the excitation: constant potential and valve rectified potential. The former is definite. The latter may include, as extremes, half-wave on an ordinary tube and half-wave on a special tube with a strongly biased filament. The filament bias may be adjusted to give a quality nearly the same as that of constant potential at the same peak value, whereas the simple half-wave will produce a much softer radiation having less average pene-

¹ Publication approved by the director of the National Bureau of Standards of the U. S. Department of Commerce.

tration. Other wave forms frequently used will give intermediate qualities.

Most quality determinations, aside from actual spectrometric measurements, are made through a series of absorption measurements in filters of a given material placed in the unknown x-ray beam. Here, the problem is complicated by the fact that true energy measurements are not made on the x-ray beam, such being impractical without very elaborate apparatus and technique. Instead, we measure the radiation in terms of the amount of ionization the beam produces in a gas. This is proportional to the fractional part of the radiation absorbed in the gas, which in turn, for a given gas, varies with the wave length of the radiation and varies between gases for the same wave length. The term "dosage rate"² refers to the ionization chamber measurement, with air as the standard gas. Air is chosen for the reasons that it is most conveniently available, is reproducible, and has an effective atomic number near that of body tissue. It should be borne in mind, therefore, that any experimental determination of quality embodies all the above factors and, hence, to a considerable extent depends upon an arbitrary agreement as to the choice of experimental technique. Different techniques involving different filter materials or different ionization chamber gases will, in general, give varied results which are usually incapable of ready correlation.

Full Semi-logarithmic Absorption Curves

—A full set of absorption data—usually given in the form of a curve showing dosage rate as a function of the filter thickness—presents the maximum information made available by the filter method of measuring x-ray quality. Having this, it has been shown theoretically (11) for constant potential excitation and checked experimentally (2), that any given spectral distribution has a particular absorption curve and that no

two different spectral distributions can give identical absorption curves. These studies have provided the desired relationship between the quality specification as conceived by the physicist and required by the radiologist.

Strictly speaking this applies only to constant potential, but it has been conclusively demonstrated (13) that a fluctuating potential produces an average spectral distribution whose absorption curve matches within practical limits, that obtained at some particular constant potential. It must be admitted, however, that if carried out to an excessive degree of filtration, such curves must diverge, since one beam will contain wave lengths shorter than any present in the other beam. But there are practical limits beyond which it is unnecessary to extend the filtration measurements. These limits differ with the different practical applications of the radiation, and by international agreement the maximum filtration—assumed in all further discussion—is specified as the amount which will reduce the dosage rate to 1 per cent of its incident value.

For convenience, the percentage transmission rather than relative transmission may be plotted so that all curves pass through the same point for zero filter. A further convenience is obtained by plotting the logarithm of the percentage transmission against filter thickness, which compresses the vertical scale and has the additional value that absorption coefficients may be obtained directly from the slope.

We have shown (13) for constant potential excitation that a semi-logarithmic absorption curve is characterized by the voltage and filtration and that curves differing in initial filtration may always be brought into coincidence through a combined shift parallel to the ordinate and abscissa—the abscissal shift giving directly the filtration difference. It was also shown that within reasonable limits an absorption curve produced by whatever excitation may be brought into coincidence with some specific constant potential curve by suitable shifts on both axes. The comparisons were made

² The x-ray dosage rate at a point in an irradiated medium is the x-ray dose (measured in roentgens) received per unit time at the point in question. From joint memorandum by NBS, NPL and PTR 1934.

for constant and pulsating voltages up to 200 kv with filtrations never in excess of 3 mm. of copper, and hence include only conditions ordinarily encountered in the therapeutic application of x-rays. Carried to higher filtrations the absorption curve for the pulsating voltage begins to rise above that for constant potential. However this portion of the curve for pulsating potential may be readily matched with some other higher constant potential curve and hence may be adequately described in terms thereof. Within the 200 kv range it has been found that, so long as that filtration does not reduce the dosage rate to less than about 5 per cent of the zero filter value, matching of the absorption curves over their full length is possible. *These studies proved that an adequate quality designation could be given by a statement of the fore-filter and equivalent constant potential.*

The important fact to be borne in mind here is that a full semi-logarithmic (or other derived) curve gives a complete description of a given beam of radiation, and that the accuracy of that description may be carried out to any desired degree by merely increasing the range of filtration and the accuracy of the measurements.

It is, of course, obvious that for many purposes obtaining a full absorption curve is unwarranted by the required accuracy of the experiment, and it is for that reason that numerous other shorter methods have been proposed and used. In the discussion which follows we wish to make clear that all these other methods are in reality, only partial descriptions of a full absorption curve, and that their degree of accuracy in describing a curve depends entirely upon the choice of technique.

Half Value Layer ($h \ v \ l$)—By half value layer or half value thickness is meant the thickness d of filtering material required to reduce the incident dosage rate I_0 to a transmitted value $I_{1/2} = 5I_0$. This may be written as $\log I_{1/2} = \log I_0 + \log 5$ or $\log \frac{I_{1/2}}{I_0} = 301$.

From this it is evident that on the semi-logarithmic absorption curve, the half

value for any initial radiation whatever gives two points on the absorption curve which differ always in ordinate by 301. Thus, referring to Figure 1, if a represents the initial radiation, and b the point whose ordinate is less than a by 301, then the abscissa difference gives the half value layer at once.³

It is obvious that having but two points, the curve is not fixed. Although knowledge of the general form of x-ray absorption curves does limit the choice somewhat, thus, to be of value, must, in addition, have the voltage as well as the initial filtration stated, to definitely fix the quality or the proper absorption curve. To overcome this difficulty, it has been proposed to use two half value layers to express the radiation quality (5). As indicated in Figure 1 the second half value layer d_2 fixes a third point c on the curve, which differs in ordinate by a constant value of 602 from the initial point a . Three points, of course, would much more nearly fix the curve, but, after all, the number of experimental observations required to fix these three points is sufficient for establishing a full absorption curve. In addition to the three points at least a rough curve must be plotted for interpolation purposes, so that for a single half value layer determination, a minimum of three and an average of five measurements must be made.

To express quality by the "two half value layer" method, two numerics must be given. Unfortunately ratios or differences between the first and second half value layers lead to multi-valued functions so that there does not appear to be any simple way of reducing to a single number the radiation quality determined in this manner. It can be done by relating the numbers through a particular absorption curve which may, in turn, be expressed in

³ This suggests a very simple method for reading half value layers from semi logarithmic absorption curves. A piece of cross section paper is cut in the shape of an elongated L and graduated on the same scale as the plotted curves. By simply placing L on the curve at any desired point the half value layer is read off directly on the abscissa scale.

some form of equivalent potential. The process is too laborious to be seriously considered.

definite, but for pulsating potential the procedure is risky, since so many wave forms are possible, for example, Witka,

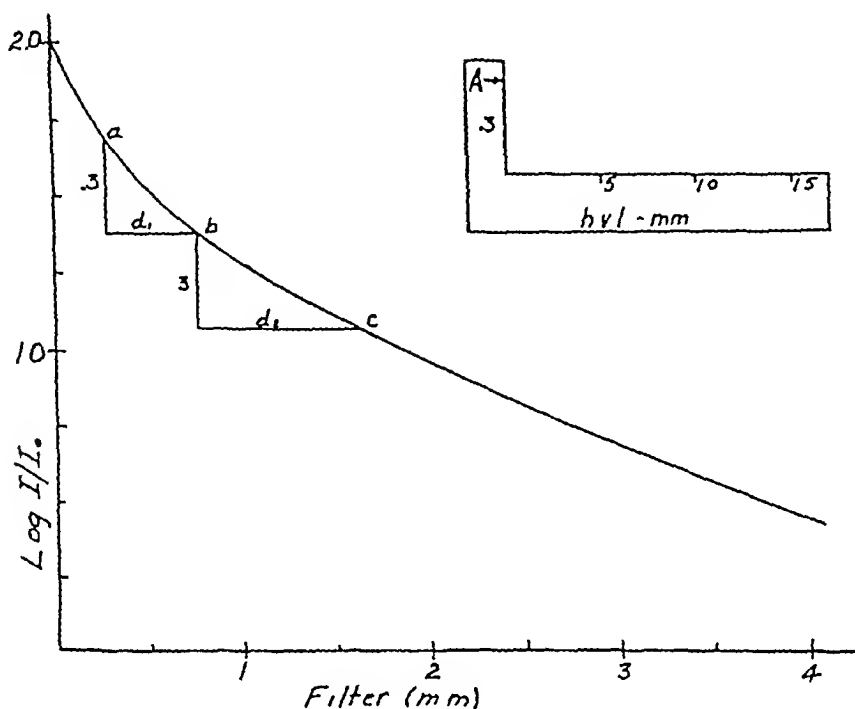


Fig 1

Half value layer measurements offer the advantage of depending only upon the kind of filter used and not upon a specific thickness, as in the case of the effective wave length (Duane, 3, 4)

In common with all the approximate methods of quality determination, the sensitivity of quality differentiation by means of the half value layer varies considerably between the low and high filtrations at a given voltage or low and high voltages for a given filtration. This lack of sensitivity might be overcome by using, say, $3/4$ or $1/5$ value layers, although, because of the added complication, this step is probably unwarranted.

Families of curves and nomograms have been set up by which means one can determine the half value layer from the voltage or filtration for both constant and pulsating potential (5, 2). The former is quite

Villard, mechanically rectified, or biased filament voltages.

Effective Wave Length—The effective wave length (Duane) of x-rays (3, 4) is given by the wave length of the monochromatic radiation which is absorbed in a given filter to the same extent as the heterogeneous beam in question. From the simple absorption law we have

$$\log \frac{I}{I_0} = -\mu x$$

$$\log I_0 - \log I = \mu x$$

where μ is the absorption coefficient and x is the filter thickness.

For monochromatic radiation this is a straight line of slope μ when $\log \frac{I}{I_0}$ is plotted against x . Referring to the heterogeneous absorption curve in Figure 2, we have μ

given by ad/λ_1 for a given filter thickness λ_1 . Using this value of μ , the effective wave length λ_e is obtained from the empirical

absorption coefficient at either end point but to some intermediate point, the relative position of this latter point depending

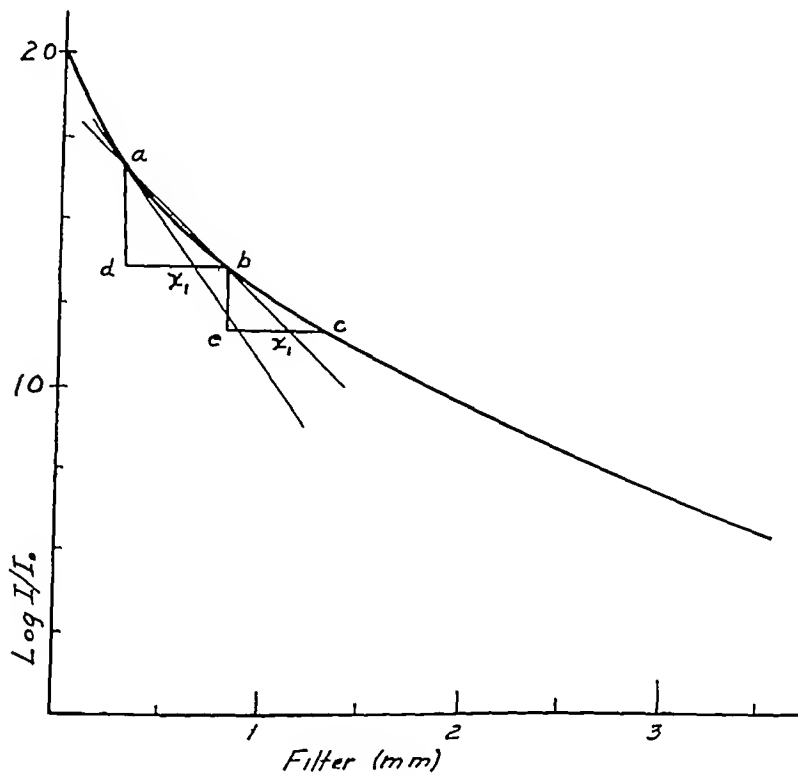


Fig 2

monochromatic wave length absorption curves or equations (9, 10)

Reduced to its fundamental significance, the effective wave length gives two points on an absorption curve separated always by a constant abscissa (as compared with a constant ordinate separation in the case of the half value layer). As proposed by Duane, the radiologist avoids the step involving use of the absorption laws and by means of computed curves is able to read directly the effective wave length in terms of the ratio of incident to transmitted dosage rate through a given filter.

Since this effective wave length is determined by the slope of a secant between two points on the absorption curve, it is obvious that it does not correspond to the

upon the position along the curve where the measurements are made.

The great advantage of this method lies in the fact that only two measurements are required. It has, however, suffered the unfortunate disadvantage that there has been a widespread use of various filter thicknesses and material in the measurements, each of which yields a different result, which is not easily co-ordinated with the others except through use of the full absorption curve. To add to the misfortune, it was only rarely that an author took the trouble to state just what material and thickness was employed in his measurement.

To specify a third point on the absorption curve, we might use a "second effective wave length" in just the same manner

as a second half value layer, but with the very considerable advantage that only three measurements would be required as compared with at least seven by the other

An attempt was made as in the half value layer case, to find a simple method of combining a first and second effective wave length into a single numeric, but this also always developed into a multi-valued function and hence was not permissible

Other effective wave length methods involve the determination of the full absorption curve. These have been designated as average wave length (7) or as true effective wave length (12), although in reality both are the same except that the former deals with portions of the absorption curve which are supposedly "straight". Since this is not physically possible in the ranges covered, it is perhaps better not to use the term "average".⁴

These methods yield the absorption coefficient at a single point on the curve from the slope of a tangent at that point, as shown in Figure 2. (This corresponds to the use of an infinitesimal filter in the Duane method.) Thus instead of giving two points on an absorption curve, these last methods yield one point and slope at that point. The two sets of conditions are about equally effective in designating a particular curve. The true effective wave length method has the slight advantage

over the Duane effective wave length in that it involves the absorption coefficient at a point on the curve corresponding to some particular filter, whereas Duane's method involves some unknown point. For highly filtered radiations this is far less important than for moderately filtered radiations (less than 0.5 mm Cu at 150 kv). Since in any case both methods are but approximations to a full absorption curve, it is probable that the simplicity of Duane's method offsets this disadvantage.

It may be well to point out that the term "effective wave length" has very little physical significance. Effective wave length is a matter of definition only and its significance in relation to other quantities (for example, absorption in water) depends entirely upon the choice of filters used in its determination. Consequently, we may reasonably question the value of its use and raise the question: Why not stop at the absorption coefficient stage in the calculations? This would give a term (effective absorption coefficient) which, while having no more ultimate significance than effective wave length, would not tempt unwarranted interpretation or uses of the latter.

Absorption Coefficient -- Newell⁵ has pointed out that use of the absorption coefficient permits an easier matching of absorption data (as, for example, a full curve). As the radiation becomes harder, the absorption coefficient tends toward a constant value. Consequently, if the derivative of a full absorption curve be plotted—thus giving an absorption coefficient curve—it is found that at the higher filtrations the curve approaches the horizontal more rapidly and that a match between curves apparently need be made in the ordinate dimension only.

This method permits a more accurate identification or matching of absorption curves in the regions of high filtration. It does, however, essentially neglect the portions of the curve corresponding to low filtrations, since the absorption coefficient is

⁴ Authors frequently refer to the straight portion of a semi logarithmic absorption curve. It has been shown (13) that under ordinary conditions (copper up to 300 kv, aluminum up to 150 kv) such a straight portion must be due to some experimental error. Wall effect in thimble chambers being the usual cause. Consideration of the simple laws of filtration will show that a heterogeneous beam cannot be made homogeneous until all but the minimum wave length are filtered out. At the higher voltages 'straight portions' may be caused by the use of a filter which is too transparent to all wave lengths comprising the radiations used. For example, aluminum used at 500 kv would yield an approximately straight curve which might be interpreted as due to homogeneous radiation. However, this would mean only that the aluminum was so transparent to all the wave lengths that there was effectively no difference in the absorption between the longest and the shortest wave lengths while actually the radiation was changing its quality with each change in filtration.

⁵ Unpublished paper presented at American Physical Society, June 1936.

changing so rapidly as to make any matching along the filter axis extremely difficult. This may be compared with the matching of the full absorption curves directly, which can be done with much greater ease at the lower filtrations than for the higher.

A greater advantage of the absorption coefficient for identifying radiation quality lies in its permitting the use of tabular data giving the absorption coefficients at certain filtrations under standard conditions which may be used for direct identification of unknown radiations having the same initial filtrations. However, when considering the various steps involved, it is difficult to see where this method offers any outstanding advantages over the effective wave length methods.

Quality of High Voltage Radiation—The foregoing discussion is equally applicable to the determination of the quality of radiations produced by potentials in excess of 250 kv. We ordinarily find, however, that high filtrations are used at these voltages and that the curvature of the absorption curve is very much less than at lower voltages. (This varies with filter material but holds true for the filter-voltage combinations in ordinary use.) This means that no great error will be encountered in defining a particular curve by means of two points, by whatever of the above methods they might

be determined. It means further that thus there is certainly no need for such measurements as a second half value layer. So long as the filter material is suited to the particular voltage range, no serious error will be involved in using any of the well-known quality measurements.

Discussion of the choice of filter material is not necessary here since it has been critically discussed by Holthusen, Mayneord, Qumby, Thoraeus Newell,⁶ and others (5, 6, 8, 14).

⁶ *Loc cit*

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DIFFERENTIAL DIAGNOSIS OF BONE TUMORS OF THE EXTREMITIES BY ARTERIOGRAPHY

By P. L. FARIÑAS, M.D., Havana, Cuba

At the Fourth International Congress of Radiology, in Zurich, José P. Caldas, of Lisbon, presented a most interesting paper, namely, "Radio-diagnosis of Bone Tumors by Arteriography." It led us to start studying by arteriography the circulation in the bone lesions with Dr. M. Robau and Dr. L. Fariñas. It is needless to point out the great importance of a method that helps in the early differential diagnosis between benign and malignant bone tumors. Arteriography is a procedure

that is applied to the patient easily, without danger, and helps materially in the diagnosis.

The technique is simple. After local anesthesia a direct puncture of the artery is made. When the sub-clavicular artery is injected, it has to be exposed, and the same applies to other arteries of the extremities when they are not easily punctured.

According to the region, from 5 to 20 c.c. of thorocontrast is injected, and immediately radiographs are taken in rapid succession.



Fig 1

Fig 2

Fig 3 A

Fig 3 B

Fig 1 Case 1 Arteriography. Direct puncture of the femoral artery. Injection of 12 c.c. of thorocontrast. The arteriogram shows slight displacement of the femoral artery by the tumor. No neoforming vessels can be seen. Benign bone tumor. Biopsy. Chondroma.

Fig 2 Case 2 Benign giant-cell tumor. History of repeated trauma at the right knee. Palpable tumor with pain and local heat. Radiography shows osteolytic tumor involving the metaphyseal and epiphyseal side of the inferior end of the femur. The epiphysis has trabecular aspect. The question of osteolytic sarcoma or benign giant-cell tumor arose.

The arteriogram shows marked compression of the femoral artery by the tumor. Lack of intra tumoral circulation. A very fine artery follows the capsule of the tumor. The diagnosis of giant-cell tumor was established. Biopsy showed giant-cell tumor.

Fig 3 A Case 3 Ewing tumor. Patient is 16 years of age. Fever and pain at the lower end of the femur. Radiograph shows an osteoblastic tumor involving the lower half of the shaft of the femur. There is expansion of the shaft and onion-peel deposit of periosteum. Diagnosis. Ewing tumor or osteomyelitis of Garré.

The arteriogram shows three broad vascular pedicles of the tumor and many new vessels running in all directions. At the border of the tumor new arteries perpendicular to the bone can be seen. There the bone spicule will be laid down later, giving the sunburst aspect. Diagnosis. Malignant tumor. Biopsy showed Ewing tumor.

Fig 3-B Case 3 The venous circulation shows irregular distribution of the new vessels with neoplastic aspect.

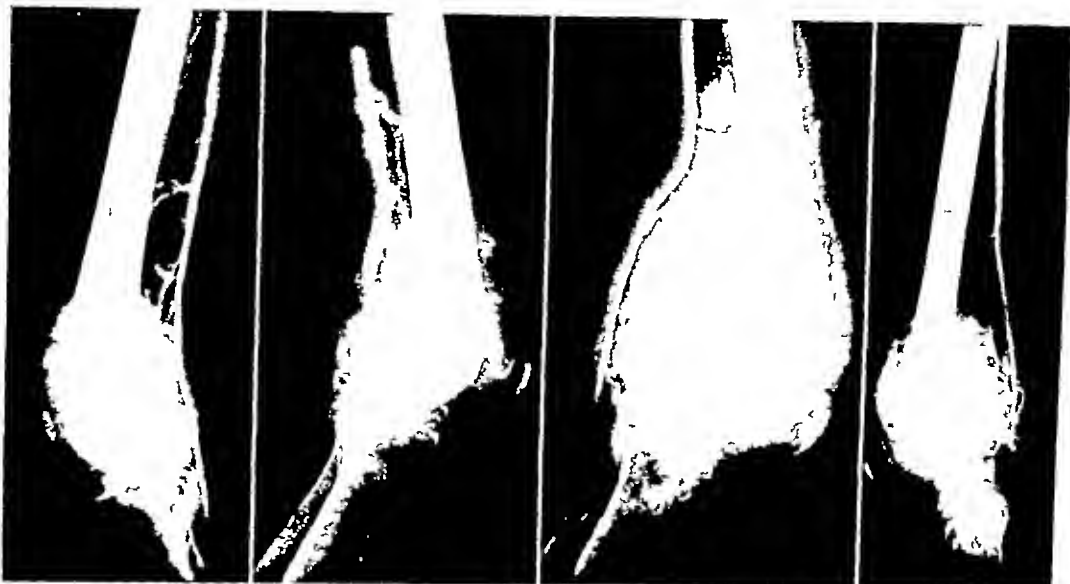


Fig 4 A

Fig 4 B

Fig 5

Fig 6 A

Fig 4-A Case 4 Sarcoma Patient is 18 years of age History of trauma Pain in lower part of femur that has increased lately Palpable tumor Radiograph shows sclerosing type of tumor with the aspect of sarcoma

The arteriogram shows several vascular pedicles, an atypical circulation with new vessels running in all directions giving the tumor a shadow beyond the bone Diagnosis Bone sarcoma

Fig 4-B Case 4 The venogram shows large femoral vein and irregular network of venous vessels at the tumor area characteristic of malignancy The venous circulation appears rapidly in the series of films—characteristic of sarcoma (Caldas) Biopsy Osteogenic sarcoma.

Fig 5 Case 5 Bone sarcoma The radiograph shows the typical aspect of osteogenic sarcoma with pathological fracture

The arteriogram shows several arterial pedicles of the tumor and many irregular new vessels characteristic of malignancy Biopsy Osteogenic sarcoma

Fig 6 A Case 6 Bone sarcoma The x-ray film shows the characteristic aspect of osteogenic sarcoma

The arteriogram shows several vascular pedicles supplying nutrition to the tumor and an irregular network of newly formed arteries running in all directions and showing the tumor in the soft tissue

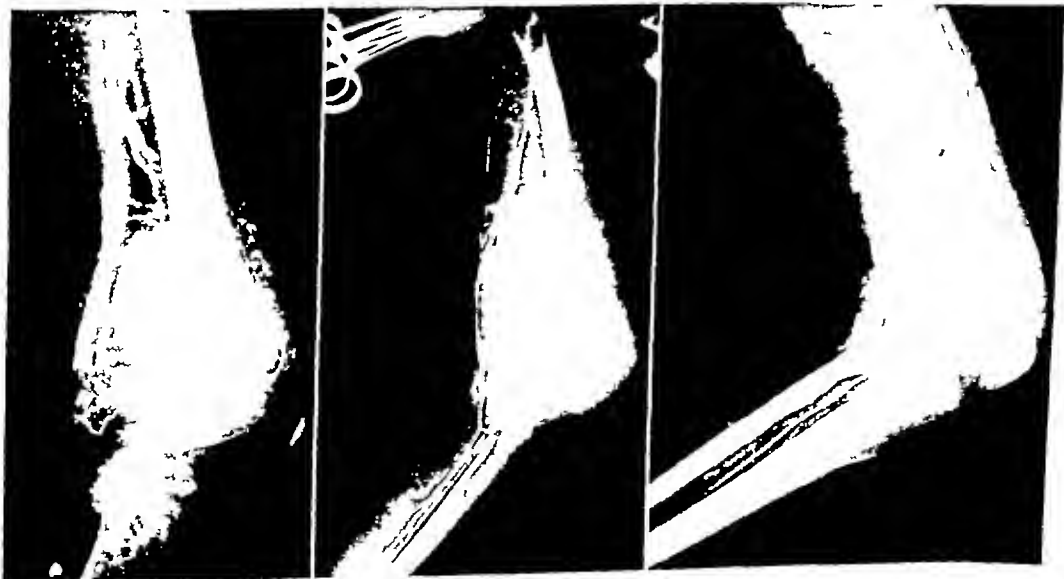


Fig 6 B

Fig 7

Fig 8



Fig 9

Fig 10 A

Fig 10 B

Fig 9 Case 9 Ewing tumor The patient is 12 years of age The x ray film shows the characteristic aspect of a malignant tumor of the femur

The arteriogram shows a typical anarchic circulation characteristic of the neoplastic processes

Fig 10 A Case 10 Malignant metastasis The patient is 35 years of age Removal of the left breast for tumor, bone metastasis at the sternum and right femur The x ray film shows an extensive malignant metastasis of the femur osteolytic in character with destruction of the periosteum and invasion of the soft tissues

Arteriogram shows direct puncture of the femoral artery after local anesthetic Injection of 12 c.c. of thorotrast The films show several vascular pedicles an intricate network of new vessels running in all directions of about the same caliber, and characteristic of malignancy

Fig 10 B Case 10 The venograph shows increased venous circulation Many irregular new vessels in the tumor area that make the tumor show plainly in the soft tissues

In order to obtain the best contrast of the circulation, it is necessary to make a good compression of the artery above the point of injection, and at times it is practical to do the same below the lesion After the first plate has been made, the compression

is released and other films are taken to show the returning circulation (venography) From the study of these films we may obtain much information relative to the nature of the tumor

In benign tumors the vessels may be dis-

(See illustrations on opposite page)

Fig 6 B Case 6 The venograph shows anarchic vein circulation Here as in the arteriograph, small vessels perpendicular to the shaft (sunburst) can be seen

Fig 7 Case 7 Osteogenic sarcoma (telangiectatic) Patient is 5 years of age Two months previously there was a trauma to the knee followed by an increasing tumor The x-ray film shows the characteristic aspects of osteogenic sarcoma

The arteriogram shows compression and displacement of the femoral artery by the tumor and an anarchic network of newly formed vessels in the tumor characteristic of sarcoma Here the character of the circulation gives a mottled aspect of the telangiectatic tumor, due to the deposit of thorotrast in the vascular sacs of the tumor

Fig 8 Case 8 Diagnosis between chronic osteomyelitis and Ewing tumor Patient, 35 years of age, complained of pain in the inferior third of the femur Lately the pain has increased, and there is swelling and fever The radiograph shows expansion of the shaft by new bone formation Periosteal reaction with onion peel aspect The arteriograms show ischemic aspect of the circulation in the affected area Arteriographic diagnosis Chronic osteomyelitis, proved by operation

placed by the newgrowth, but they are regular in caliber and number (Case 1)

The giant-cell tumors do not show intratumoral circulation, but we see an artery following the capsule (Case 2)

In malignant tumors we observe several vascular pedicles nutritioning the newgrowth and an irregular network of newly formed vessels of the same caliber running in all directions (Cases 3-6) Among the group of sarcomas we may differentiate some special types, such as the telangiectatic tumors, by the character of their circulation, multiple pedicles, an extended network of newly formed vessels running in all directions, anarchic in character, a special characteristic of these tumors being

a mottled aspect due to intratumoral vascular sacs (Case 7)

At times it is very difficult to make a differential diagnosis between chronic osteomyelitis and some malignant tumors, such as Ewing's. In such cases arteriography is a method of great importance in differentiating. In chronic osteomyelitis we see a decrease in the number and caliber of the arteries due to ischemic process, on the contrary, in the Ewing's tumors we see the characteristics of the neoplastic tumors (Cases 8 and 9)

The metastatic malignant tumors show the same characteristic anarchic circulation (Case 10)

GANGRENE OF FACE PRODUCED BY LYMPHOSARCOMA

By E M SHEBFSTA, M D, *Detroit, Michigan*

From the Radiologic Services of Dr Stevens, Dr Jarru, and Dr Hasley, Grace Hospital

THIS paper was considered worthy of publication because of the confusing manifestations which this case presented. We have been unable to find in the literature a description of a similar case. However, Craver and Copeland (2) mention that one of their cases had involvement in the maxilla, and Schreiner and Herger (9) mention that one of their cases had involvement of the nose and two involvement of the nose and antrum.

Craver and Copeland (2) studied 164 cases of lymphosarcoma at the New York Memorial Hospital, of which 17 revealed bone involvement. According to their studies, the bones involved in order of their frequency were spine, pelvis, skull, femur, humerus, tibia, scapula, mandible, fibula, and ribs. All of their patients except one had lymph node involvement prior to demonstrable bone changes. Our case revealed no lymphadenopathy for several months following the onset of his symptoms.

Case Report—A white male, aged 33, dated his illness to November, 1935, when he noticed a swelling in his nose accompanied by a profuse, foul-smelling, gray-colored, watery discharge. Because of this profuse nasal discharge, he was unable to keep his job as a city bus driver. In January, 1936, he was referred to a surgeon for relief of the marked nasal obstruction. The benefit in this instance was of extremely short duration, and in March, 1936, further resection was necessary. Following this second operation, the disease appeared to progress very rapidly. In June, 1936, he was admitted to the University of Michigan Hospital, and referred to the Otolaryngology Department. Dr A C Furstenburg, Professor of Otolaryngology, was kind enough to send us the following summary of their findings:

'Our examination was as follows. The left ear was negative. The right tympanic membrane was largely destroyed but the tympanum was dry. The nose showed the right chamber to be full of mucus. The left nasal chamber was full of pus and crusting. The mucous membrane of the inferior turbinate was granular. Bare bone was felt with a probe on the lateral wall of the nose. The nasopharynx showed a swelling of the soft tissues almost filling the left posterior choana. In the mouth, the mucous membrane was destroyed over the left half of the hard palate and alveolar ridge, covered with slough, and when removed showed bare bone. The face presented a swelling over the left cheek and eye, very tender to palpation. We advised admission to the hospital for further observation and investigation.

'The blood Kahn was negative. A complete blood analysis was essentially normal, except for a mild leukocytosis of 14,000 white blood cells. X-ray examination was as follows: Minimal thickening, mucous membrane lining, right maxillary sinus. Clouding of left maxillary, left ethmoid and left sphenoid sinuses. Apparent increase in soft tissue, left nasal chamber. Suggestive evidence of increase in soft tissue, left margin of nasopharynx, extending laterally in an area posterior and inferior to left maxillary sinus. No demonstrable bony destruction. Tuberculous scars, both upper lung-fields, probably inactive.'

'The patient was seen by the Department of Dermatology and the lesion was thought to be neoplasm, but the possibility of a gumma or rhinoscleroma was also suggested. Biopsy specimens from the nose and mouth were reported as follows: Destructive ulcerating process. Necrosis of bone. Productive osteomyelitis. Heavy plasma cell changes. Obliterative changes in some of the blood vessels. The appearances are those of an ulcerating granuloma rather than neoplasm, although we cannot exclude the possibility of an underlying neoplastic disease. The biopsy specimens show primarily inflammatory lesions and upon these we make a presumptive diagnosis of ulcerating destructive syphilis.' Not satisfied with the first biopsy, another was taken and was reported as follows: 'This second biopsy shows the same changes as the preceding specimen, and, in addition, somewhat further away

placed by the newgrowth, but they are regular in caliber and number (Case 1)

The giant-cell tumors do not show intratumoral circulation, but we see an artery following the capsule (Case 2)

In malignant tumors we observe several vascular pedicles nutritioning the newgrowth and an irregular network of newly formed vessels of the same caliber running in all directions (Cases 3-6) Among the group of sarcomas we may differentiate some special types, such as the telangiectatic tumors, by the character of their circulation, multiple pedicles, an extended network of newly formed vessels running in all directions, anarchic in character, a special characteristic of these tumors being

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The metastatic malignant tumors show the same characteristic anarchic circulation (Case 10)

pate a definite lymphadenopathy in both submandibular regions. This was thought to be an adenitis rather than a metastatic involvement. Following the administration of approximately 600 r units (measured with back-scatter) over a period of 17 days, employing the same factors as mentioned above, the adenopathy subsided. This led us further to the belief that we were dealing with an inflammatory condition. During the next five weeks the patient was given approximately 75 r to the face at weekly intervals, but the marked necrosis continued rapidly in spite of the roentgen therapy. At no time did the ulceration over the face show anything but a sharp, smooth border very similar to that of a gumma. The patient became progressively more toxic, and on September 9 began to show evidence of pneumonia over the left lower lobe, with rales over the right upper lobe. On Sept 11, 1936, he expired.

Autopsy—The significant findings were as follows (Dr C I Owen, pathologist)

"External description The patient was markedly emaciated and cachectic. The left side of the face, including the cheek and all of the maxilla, was gangrenous so that the pharynx was clearly visible through the cheek. The eyelids on the left side were swollen.

"The other positive findings were as follows There was necrosis of the floor of the left orbit. There was a mass, approximately 7 cm in diameter, firmly adherent to the left mandible, which proved to be metastatic involvement in a lymph node. The right lung revealed pneumonitis in the upper lobe and the upper portion of the lower lobe was adherent posteriorly. The left lower lobe showed massive consolidation. In the abdomen the lymph nodes were enlarged. The liver exhibited irregularly shaped grayish areas which proved to be metastatic nodules. Lymphadenopathy was also present in the inguinal region, but these nodes were only about the size of a pea.

"Microscopic The lymph nodes exhibited almost complete necrosis. A loose fibrillary stroma remained with cells of the reticulum-cell type irregularly scattered throughout the tissue. Apparently it was the tumor tissue that was necrosed. The spleen was not involved in the process. The liver exhibited much degeneration of the parenchyma. It contained tumor tissue which was unencapsu-

lated and which had a fibrillary stroma associated with it. The tumor cells were somewhat anaplastic, had hyperchromatic cells, little cytoplasm, and included a few mitotic figures.



Fig 3 Section from a large metastatic nodule which is visible in Figure 2. Note the small round cell infiltration.

Tumor tissue of a similar type was present in the skin and involved both the subcutaneous and epidermis.

'Pathological diagnosis Lymphosarcoma, general in lymph nodes and involving liver and spleen. Gangrene of the left side of the face."

Comments—In spite of two biopsies, the correct diagnosis in this case was not made until autopsy. The biopsies were taken from the nasal turbinates. The diagnoses strongly considered were syphilis, rhinoscleroma, reticulocytoblastoma, carcinoma, and mycotic infection. Clinically, we regarded this as an infection rather than a neoplasm, and consequently the condition was under-treated. It seems most likely that the disease originated in the maxillary sinus and next involved the nasal structures. Unlike the usual case of lymphosarcoma, the lymph nodes were not palpable until after the face showed gangrene. Craver and Copeland (2) found metastatic lymph node involvement in all but one of their 17 cases prior to the bone changes.

from the ulcerating surface, there is an undoubted neoplasm which is the underlying pathology. This is a round-celled neoplasm with abundant stroma. The cells are largely lacking in differentiation. As far as histo-

nose. The patient had a temperature of 100°F , leukocyte count was 15,000 with 80 per cent polymorphonuclear leukocytes. He complained of a mild degree of pain over



Fig 1

Fig 2

Fig 1 Note the marked swelling over the left side of face and the beginning ulceration. A very foul odor accompanied the condition.

Fig 2 This shows the patient two weeks later. The swelling subsided considerably after roentgen therapy but note that the ulceration has progressed and that a marked adenopathy has developed. Two months later the pharynx was visible through the gangrenous cheek.

logical evidence goes, it might be a reticulocytoblastoma or an undifferentiated cell carcinoma. We favor the second interpretation.

"During the patient's stay in the hospital, he remained quite comfortable, and received treatment of saline throat irrigations frequently during the day. We believe this lesion of the maxilla and nose is a carcinoma and obviously the prognosis is quite poor."

On June 26, 1936, the patient was referred to Dr. Rollin H. Stevens, at Grace Hospital, for roentgen therapy. Our findings at that time were very similar to those mentioned above by Dr. Furstenburg, except for the presence of more swelling over the left side of the face. Roentgen examination of the facial bones at this time revealed a picture similar to that mentioned above, but in addition, one noted a slight degree of erosion of the floor of the left maxillary sinus and complete opacity of this maxillary sinus. At that time, there was no ulceration of the face, but there was marked inflammatory reaction over the left cheek and the left half of the

the left cheek. On admission, he was given 123 r to the left side of the face, employing a 20×20 cm cone, FSD 50 cm, 200 kv, 25 ma, filter 2 mm Cu, plus 1 mm Al, at the rate of 24.5 r per minute, measured with back-scatter. We believed we were dealing with an inflammatory condition rather than a neoplasm, and the patient improved markedly following the first treatment, that is, there was apparently complete disappearance of the inflammatory reaction. However, two days later we noted a lesion approximately 1 cm in diameter over the left cheek, adjacent to the ala nasi, which suggested the presence of a furuncle. A gumma was strongly suspected. However, the blood Kline, Eagle, and Kahn tests were all negative on several examinations. The patient was given similar roentgen treatments on July 2 and July 7. Nevertheless, the ulceration of the face progressed very rapidly. Figure 1 shows the patient's face six days following admission. On July 2, we were able to pal-

MILIARY CALCIFICATIONS IN THE SPLEEN

By THEODORE M. BFRMAN, M.D., *Minneapolis, Minn*

From the Department of Radiology, University of Minnesota and University Hospital

CALCIFICATION in the spleen is an occasional incidental finding in roentgenograms of the abdomen. As might be expected, the etiologic factors are numerous. Larger areas of calcification measuring up to from two to three centimeters in diameter are uncommon and may be caused by echinococcus cysts, old infarcts, healed abscesses, rarely by bone-forming metastases, and the so-called primary tuberculosis of the spleen occurring in young adults. In the latter disease, marked splenomegaly associated with large granular areas of calcification constitutes a pathognomonic picture (4).

The usual calcification observed in roentgenograms of the spleen is the multiple, milinary form presenting numerous small rounded densities averaging from three to five millimeters in diameter. This is the

opinion that these densities represent the end-results of calcified milinary tuberculosis of the spleen. In some instances, perhaps, too much importance has been attached to this finding because of the implications inherent in the presence of tubercles anywhere in the body. Clarification of the origin of such shadows is, therefore, highly desirable.

There has been a lively controversy in the German literature as to the nature of these densities. Barsony and Schutz (1), in a convincing study, radiographed 180 spleens from a series of unselected autopsies and found seven cases of milinary calcification, an incidence of almost 4 per cent. All were 50 years of age or older. Histologic study in each instance revealed the calcifications to be phleboliths of the splenic veins.

TABLE I

Case	Age	Sex	Chest Roentgenogram	Clinical History of Tuberculosis	Autopsy	Probable Etiology of Calcification
1	13	F	# Multiple	None	No	Tuberculosis (?)
2	28	M	N	None	No	Doubtful
3	29	F	# Quiescent	None	No	Tuberculosis (?)
4	35	M	*# Quiescent	Urogenital tract	No	Tuberculosis (?)
5	35	M	#	None	No	Doubtful
6	40	M	#	None	No	Phleboliths
7	46	M	# and ## Calcified	None	No	Tuberculosis (?)
8	48	M	#	None	No	Phleboliths
9	49	M	O	None	No	Doubtful
10	51	M	O	None	Yes	Phleboliths
11	56	F	#	None	No	Phleboliths
12	62	M	# (by autopsy)	None	Yes	Phleboliths
13	67	F	N	None	No	Phleboliths
14	68	F	N	None	No	Phleboliths
15	68	M	N	None	No	Phleboliths
16	73	F	# (by autopsy)	None	Yes	Phleboliths
17	82	M	N	None	No	Phleboliths
18	88	M	#	None	No	Phleboliths

#, Calc. primary focus

*# Adult tuberculous lesion

N, Normal lungs

O No film made

type that will be considered in the present paper. Phleboliths (calcified venous thrombi) and tubercles are the most frequent causes, with calcifying hyaline perisplenitis a rare factor. There is a general

Courtin and Duken (2), working with pediatric material, found milinary calcifications in the spleen associated with active tuberculosis in other organs. They interpreted these as tuberculous in nature and

Summary—A case report was presented, which showed extensive gangrene of the face produced by lymphosarcoma. The primary manifestations were nasal obstruction and nasal discharge. The neoplasm apparently originated in the maxillary antrum. The lymph nodes were not involved until late in the disease. Correct diagnosis was not established in spite of biopsies.

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the splenic calcifications here is doubtful. The patient's age favors tuberculosis, but the absence of lung pathology favors phleboliths. Cases 5 and 9 are also doubtful but probably represent phleboliths.

All the remaining cases (Nos. 6, 8, and 10-18) gave no clinical history of tuberculosis. In four, films of the chest showed no pathology, six exhibited calcified Ghon's tubercles. Three came to autopsy (Cases 10, 12, and 16), including two which showed calcified primary tuberculous lesions in the lungs. Histologic study of all three showed the calcifications to be phleboliths. This intimates strongly that the mere presence of a Ghon's tubercle does not indicate the tuberculous nature of milary splenic calcifications.

ROENTGEN FINDINGS

These lesions may be discovered in a routine film of either the chest or abdomen. They vary in number from a dozen to several hundred, and in size from one to eight millimeters, averaging four or five. They are dense, sharply outlined shadows, usually round, but varying in shape, depending on the angle the central ray forms with the long axis of the thrombosed vein. The center of the calcified areas may be denser than the periphery, but this is not constant. In this series we were unable to find any distinguishing characteristics between the phleboliths and the calcifications ascribed to tuberculosis. Figure 1 shows the typical appearance in the roentgenogram. Figure 2 is a film of the spleen made postmortem to show the character of shadows known to be phleboliths.

PATHOLOGIC FINDINGS

The lesions may be found under the capsule of the spleen and scattered anywhere throughout the parenchyma. They tend to follow the course of the larger veins in the trabeculae, whereas tubercles are in the pulp itself. Microscopically (after de-

calcification) the phlebolith presents a granular center which is more densely calcified than the periphery. About this central core the structure becomes fibrillar and looser, with fewer granules of calcium. This layer merges with the atrophying vein wall and evidences of old organization of a thrombus can often still be made out. A section was made of a non-calcified nodule. This also presents a hyalinizing structure of capillaries and fibrous tissue indicative of organizing thrombus. Figure 3 shows the typical microscopic appearance, characteristic of phleboliths. It would appear, therefore, that most milary calcifications of the spleen are phleboliths. If the patient presents evidence of tuberculosis of the lungs or elsewhere, then the splenic calcifications may be tuberculous in origin, particularly in children and young adults. The presence of calcified Ghon's tubercle only does not necessarily indicate that the lesions are tuberculous in nature, except in children. In adults the vast majority of cases can definitely be classed as phleboliths and probably should be so considered until proven to be tuberculous.

SUMMARY AND CONCLUSIONS

1. The literature on milary calcification of the spleen is briefly reviewed.
2. Eighteen additional cases are presented.
3. Histologic studies of three cases are reported.
4. Most of the milary calcifications of the spleen observed roentgenologically represent phleboliths rather than healed tubercles.

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were able to obtain microscopic proof in one autopsied case. Few other histologic studies have been made, and in the American

In the past three years we have observed 18 cases of milary calcification in the spleen, discovered accidentally during the



Fig 1 Left upper quadrant showing typical appearance of numerous calcified nodules in the spleen. These are characteristic of the appearance of phleboliths.

Fig 2 Spleen at autopsy showing typical rounded calcified nodules which proved to be phleboliths.

literature very little has appeared on this subject.

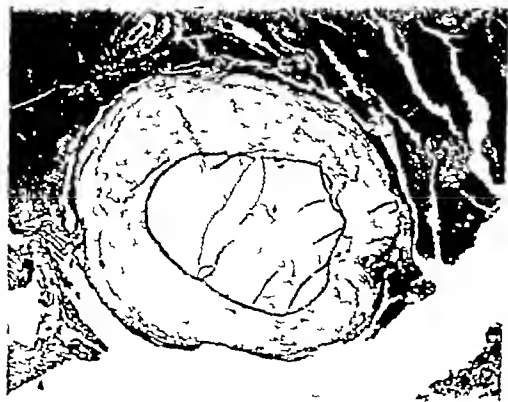


Fig 3 Microscopic section after decalcification from spleen shown in Figure 2. Note splenic pulp above atrophying vein wall fibrillar structure with some calcium and dense granular center. The appearance is characteristic of an organized calcified thrombus.

course of x-ray examinations of the chest and abdomen. Sixteen were from the University of Minnesota Hospitals, and two were studied through the courtesy of Dr L G Ericksen and Dr F P McNamara, of the Finley Hospital, Dubuque, Iowa. The cases are listed in Table I, in chronological order. Ten were males and six females. Thirteen were 40 years of age or older. Three cases (Nos 3, 4, and 7) showed a quiescent adult type of pulmonary tuberculosis. Case 1, a girl 13 years of age, presented multiple calcified Ghon's tubercles in the right lung. Of these four, only one (No 4) gave a clinical history of tuberculosis (urogenital). We have no histologic proof in any of these cases, but it is logical to admit the probability of the tuberculous nature of the splenic calcification.

Case 2, 28 years of age, had a normal chest roentgenogram, and the etiology of

period. They could not be distinguished from a smaller group of 28 animals which were not radiated and thus used for controls. On an average the thyroids of the radiated animals were grossly and microscopically indistinguishable from those of the controls. Sections of the radiated glands failed to reveal any histologic changes which could be attributed to radiation, neither destruction nor fibrosis was found in any of the radiated thyroids. Likewise the activity of the thyroids seemed to be unaffected by the radiation, as the epithelium remained a low cuboidal, the acini medium, the colloid firm, and no interacinar changes were evident.

Experiment II—Compensatory Hypertrophy after Radiation—The animals used in Experiment I were again used in this second study. In the 28 controls, or non-radiated animals, one and a half lobes of the thyroid were removed and the residual half lobe was permitted to remain for from 14 to 22 days before excision. Similarly, in 23 of the radiated animals in Experiment I, all of which had received from 100 to 150 mg.-hr. of radiation from 1 to 58 days before operation, one and a half lobes of the thyroid were removed, and the remaining half lobe was excised from 14 to 22 days later.

Of the controls, 20 of the 28, or 71.4 per cent, of the animals with thyroid residue showed signs of a compensatory hypertrophy, characterized by increase in the height of the epithelium from flat to columnar or cuboidal, smaller acini with occasional infoldings, definite depletion of colloid, and in some cases interacinar lymphocytic infiltrations. Only six of the 23 radiated animals, or 26.1 per cent, demonstrated these characteristics of a compensatory hypertrophy. None of the radiated animals showed any signs of histologic reaction to the radiation.

Experiment III—Intraperitoneal Injection of the Acid Extract of the Anterior Pituitary after Radiation—For this series we used 13 animals of larger size, weighing from 400 to 600 grams. Six were controls and seven were radiated. The latter were

given 300 mg.-hr. of radium over the thyroids from six to ten days previous to the time of starting the injections. The acid extract of the anterior pituitary was then given intraperitoneally to the 13 animals, 0.5 c.c. the first day and 1 c.c. daily for the next five days. All thyroids were removed on the seventh day.

During this experiment all of the guinea pigs lost from 30 to 90 grams in weight, the larger animals losing more than the smaller. There was no evidence of any relation between the weight loss and thyroid histology. The usual reactions to these injections such as increase in cardiac rate, extreme irritability, and exophthalmos, were noticed to be approximately as marked in the controls as in the radiated animals.

Grossly all of the thyroids appeared larger than normal but were not weighed. Microscopically all of the specimens showed hypertrophy and hyperplasia. However, the reaction was much more marked in the controls than in the radiated animals. For example, in all of the radiated thyroids there was much cuboidal epithelium, and in two cases areas of normal flat epithelial cells were found, whereas in the six controls the thyroid epithelium was entirely columnar except for scattered areas of cuboidal epithelium in three cases. Similarly, the acini in the controls were on the average much smaller than in the radiated animals, much less colloid was found in the controls, and epithelial invaginations were much more frequent than in the radiated animals. Areas of normal appearing thyroid were found in four of the radiated thyroids and in none of the controls.

In this experiment we again failed to find any histologic signs of destruction which could have been attributed to radiation.

DISCUSSION

The histologically demonstrable resistance of the normal thyroid to even very extensive radiation is a well established fact. For example, Bower and Clark (1) inserted 12.5 mg. radium needles directly into the thyroids of dogs, permitted the needles to remain from 2 to 13½ hours,

RADIATION OF THE THYROID¹

AN EXPERIMENTAL STUDY IN RADIOSENSITIVITY OF THE THYROID

By CLARENCE T ECKERT, M D, J G PROBSTEN, M D, F A C S,
and SIM GALINSON, M D, St Louis, Mo

From the Surgical Department and Laboratory of the Jewish Hospital

THE term "radiosensitivity," as with all comparative expressions, is at times ambiguous and misleading. This is particularly the case when the term is used in describing newgrowths. Normal tissue, however, is much more constant and reliable in its reactions to radiation. With this in mind, normal thyroid has been classed as a very radioresistant tissue.

The low standing of normal thyroid in the scale of radiosensitivity is based upon the fact that relatively large amounts of radiation fail to alter the histology or physiology of the gland. This is an unusual and unexpected finding in a part with such a high epithelial content and extreme histologic mutability, factors which tend to increase radiosensitivity.

It was our purpose to further study the effects of radiation upon normal thyroid. In addition to the usual method of radiating the thyroid and examining the latter for microscopic changes, we also studied the effects of radiation of the thyroid with reference to the reaction of the gland to certain stimuli. We used two methods to stimulate thyroid activity: one was the removal of one and a half lobes of the thyroid which results in a later compensatory hypertrophy of the remaining half lobe, the second method was the intraperitoneal injection of the acid extract of the anterior pituitary which causes a marked thyroid hypertrophy and other changes which closely simulate exophthalmic goiter. By radiating the thyroids previous to subjecting them to the above methods of stimulation, we hoped to throw light upon the radiosensitivity of the thyroid cell from a somewhat different source.

EXPERIMENTAL METHODS AND RESULTS

All of the animals used were young guinea pigs of both sexes, weighing from 200 to 400 grams, and all were on the same diet throughout the experiment. As a source of radiation we employed radium, using five 10-mg needles and one 50-mg capsule. All applications were made at a distance of 1 cm, for which we used a wood block. One-half mm of lead was used for screening. In order to limit the radiation to the thyroid, the application was given through a lead fenestrum which was bent so as to fit closely around the thyroid area.

In order to more thoroughly observe the histologic changes caused by the experimental procedures, serial sections were made of all the thyroids, including the controls. To judge the amount of reaction to the radiation we observed for the usual destructive changes such as loss of staining quality, enlargement of nuclei, pyknosis, etc.

As an index of thyroid activity we considered the usual criteria such as:

- 1 Height and condition of epithelium
- 2 Size and shape of acini
- 3 Amount and condition of colloid
- 4 Interacinar changes such as lymphocytic infiltration, colloid deposits, etc.

Ether anesthesia was used for all operative procedures and for destroying animals to obtain specimens.

Experiment I—Radiation to the Normal Thyroid—For this part of the work we used 40 animals and gave from 50 to 400 mg-hr of radiation to the thyroids. The latter were then removed, from 1 to 58 days after the applications.

All of the guinea pigs in this group behaved in the usual manner and showed normal gains in weight during the stated

¹ This study was aided by a grant from the David May Research Fund of the Jewish Hospital.

essary for the production of exophthalmos first, a relative or absolute deficient thyroid secretion, and second, an excess of thyrotropic factor. We can only assume that non-destructive doses of radiation, as applied previous to the administration of the thyrotropic anterior pituitary extract, are insufficient to influence, or possibly do not affect, the production of exophthalmos.

We feel that our work indicates that the radiosensitive portion of the thyroid gland is the parenchyma itself. More directly, we may infer that radiation decreases the reproductive power of the thyroid epithelial cell. Since nuclear activity causes cell division, the nucleus is the apparently radiosensitive portion of the thyroid cell. Thus we have shown that the degree of radiosensitivity is not necessarily indicated by variations in the amount of cell destruction. It is probably, as Von Wasserman (8) suggests, that the selective action of the radiation may merely destroy the proliferative power of the cell and leave it in a rather purely vegetative condition. Another observer, Prime (8), makes the interesting statement: "It is probable that the nucleus of the physically functioning cell is as much damaged as that of the inactive type but that as such cells expend their metabolic surplus in mechanical movements and not in increasing in size and dividing, as do the connective tissue and cancer cells, the effect of radium is not evident."

In considering the clinical application of this work, it is not our purpose to present radiation of the thyroid as a method in opposition to surgery. Most of the literature from either source is decidedly partial, and as Portmann (9) says, "usually arguments about the subject are based upon prejudices and simply amount to presentations of the objections to each procedure rather than the benefits." However, it seems that a method of treatment (radiation) which so definitely impairs the ability of the thyroid parenchyma to reproduce, should be of untold value in the therapy of hyperthyroid states. Even should the radiation fail to change the physiologic state

enough to effect a cure, and surgery become necessary, it seems logical to assume that the decreased reproductive potentiality of the thyroid cell would lessen the possibility of recurrence. In fact, one observer, Quigley (10), states that he did not know of a case "that has been properly treated with radium radiation even though the radium radiation has been unsuccessful in controlling the symptoms, that has recurred following a subsequent surgical operation. Apparently the radium radiation reduces the likelihood of recurrence or prevents it altogether."

CONCLUSIONS

1 Moderate radium irradiation—50–400 mg-hr at 0.5 cc distance with 0.5 mm of lead for screening—will produce no histologic changes in thyroids of guinea pigs.

2 Such radiation in doses of from 100 to 300 mg-hr will definitely impair the ability of the thyroid parenchyma to reproduce as shown by compensatory hypertrophy and the reaction to the intraperitoneal injection of the acid extract of the anterior pituitary.

We wish to thank Dr Samuel H Gray for his many valuable suggestions throughout the progress of the experiment.

We also wish to thank Dr Leo Loeb for the acid extract of the anterior pituitary used in this work.

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and removed the glands for section in from seven to 210 days. They found, immediately surrounding the needle site, the usual area of destruction which began to organize and heal after the third week. However, no changes of parenchyma or blood vessels were observed outside the destroyed area. Their observation of the apparent resistance of the thyroid to the rays led them to make the interesting conjecture that "whether this resistance is due to the colloid contained in the thyroid, to the adult fixed character of the cells composing it, or to a deficiency in autolytic ferments, we are not prepared to state, but comparison of results with those obtained in other organs and tissues rich in enzymes and autolytic ferments would point toward the latter as a possible explanation."

Friedman and Blumgart (2) met this "resistance" in attempts to permanently lower the basal metabolic rate in cases of chronic heart disease by the administration of extensive x-ray treatments to the thyroid. The roentgen irradiation failed to produce any persistent lowering of the basal metabolic rate and, in the instances in which the thyroids were later removed, microscopic examinations of the gland showed normal thyroid.

Consequently it was not unexpected that the relatively moderate doses of radiation employed in this experiment should fail to produce histologic changes in the normal thyroid. No attempt was made in this work to explain why normal thyroid is so resistant to radiation (with reference to histologic changes). It is our opinion, however, that the tremendous blood circulation of the thyroid, calculated to be 500 cc per 100 gm of thyroid per minute (3), tends to dissipate the effects of radiation.

We found no evidence, either grossly or microscopically, of stimulation in the thyroids which had been only radiated. The radiation seemingly did not cause any epithelial proliferation or "resorption of the products of secretion of the glands," *i.e.*, colloid, as found by Florentin and Watrin (4), after irradiation with x-ray using "two

short radiations of the tracheal region with weak doses."

Compensatory hypertrophy of the thyroids in guinea pigs is a phenomenon subject to wide variations. However, our figure of 71.4 per cent in the controls compares favorably with that of Loeb (5), who found that 63.5 per cent of his animals showed hypertrophy during all of the months except June, July, August, and September. Our work was done from January to May, running the controls and the radiated animals simultaneously. Thus it would seem that with the finding of compensatory hypertrophy in only 26.1 per cent of the radiated thyroids, we have the right to conclude that the radiation definitely impaired the ability of the gland to hypertrophy. Walter, Anson, and Ivy (6) performed an experiment which seems to further substantiate this conclusion. By the use of x-ray they were able to definitely decrease, but not entirely prevent, the hyperplasia of the thyroid gland that occurs in opossums on a high protein (meat) diet.

The hypertrophy and hyperplasia as produced in the guinea pig thyroids by the intraperitoneal injection of the acid extract of the anterior pituitary, presents a picture of excessive thyroid activity, both clinically and microscopically. For more detailed information concerning this phenomenon, one can refer to the many excellent papers of Loeb and his co-workers. While none of the seven radiated animals in this group showed entirely normal histology following the injections, there was no doubt that in all of the six non-radiated controls thyroid activity was much more marked. Also the fact that sections of four of the radiated thyroids showed definite areas of normal appearing gland would indicate, again, that radiation definitely impairs the ability of the thyroid cell to reproduce.

An interesting observation was the failure of the radium to influence or prevent the exophthalmos produced by the intraperitoneal injections. Marine and Rosen (7) claim that at least two factors are nec-

A BIOLOGIC TEST OF THE INVERSE SQUARE LAW AS APPLIED TO ROENTGEN RADIATION

By H. DABNEY KERR, M. D., *Iowa City, Iowa*, and TITUS C. EVANS, Ph. D., *College Station, Texas*

From the Departments of Radiology and Zoology, State University of Iowa

THE authors have been interested in the employment of grasshopper eggs as a biologic test material for effects of roentgen radiation. The first paper dealt with the quantitative responses of this material to variations in amounts of radiation (3), the next report related to effects of developmental activity on biologic responses to radiation (4), and a third gave the biologic effects of radiation on the different stages of development (5). It has been generally accepted that the intensity of radiation falls off inversely as the square of the distance, and the measurement of the intensity by physical means is in close accord with this law. Yet the writers have been unable to find a paper dealing directly with a biologic test of this generalization. The experiments to be reported in the present paper were undertaken to determine whether or not the biologic effectiveness of the radiation on these organisms falls off inversely as the square of the distance.

MATERIAL AND METHOD

The biologic material employed was the egg of the grasshopper, *Melanoplus differentialis* (unless otherwise indicated). The reader is referred to the papers of Bodine (1 and 2), and Slifer (11) for the details of its development. Eggs were collected each day and immediately placed at the incubation temperature (25° C). The age of the eggs was calculated by the number of days at the developmental temperatures, and samples were checked by dissection and observation under the binocular dissecting microscope.

The source of the radiation was a Coolidge, broad-focus, Universal tube, and was operated at 130 kv and 5 ma. The intensity was measured by means of the commercial

Victoreen dosimeter. In order to eliminate back-scatter, the organisms were placed on a cloth supported at a known distance under the target of the tube.

EXPERIMENTAL

The first experiments consisted of raying eggs with exposures of one minute at different distances. It was found that at the intensity at the shortest distance employed (30 cm) was 200 roentgens per minute, the dosage rapidly fell to that which was below the level of sensitivity of the eggs. Biologic effects at distances of 10 to 30 cm were consistent, however, and closely approached the curve of the inverse square law. With more extensive changes in intensity, the results were not consistent. It was, therefore, decided to use a higher dosage, which would make the maximum effect so great that marked changes in distance would not lower the dosage too greatly. Therefore, in other experiments of the same nature the exposure time was increased to one and one-half minutes which made the initial dose 300 roentgens. The number of eggs affected at the shortest distance (30 cm) was almost 100 per cent and the effect did not approach zero until the maximum distance (80 cm) was reached. It is thus indicated that one factor in such experiments is the range of dosages involved.

Figure 1 shows the results of several experiments in which the exposure time was kept constant and the distance varied. The intensity and dosage, measured by the dosimeter, follow the theoretical curve of the inverse square law, and are shown by the curve labelled "intensity and dosage." Curve No. 1 represents the average reaction in seven experiments using eggs from one to two days of age. There were 11

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effect of increased distance on the biologic response of five-to-six-day eggs The variation of the biologic reaction from the

The effect of the character of the biologic material on the type of response to increased distance is even more marked in

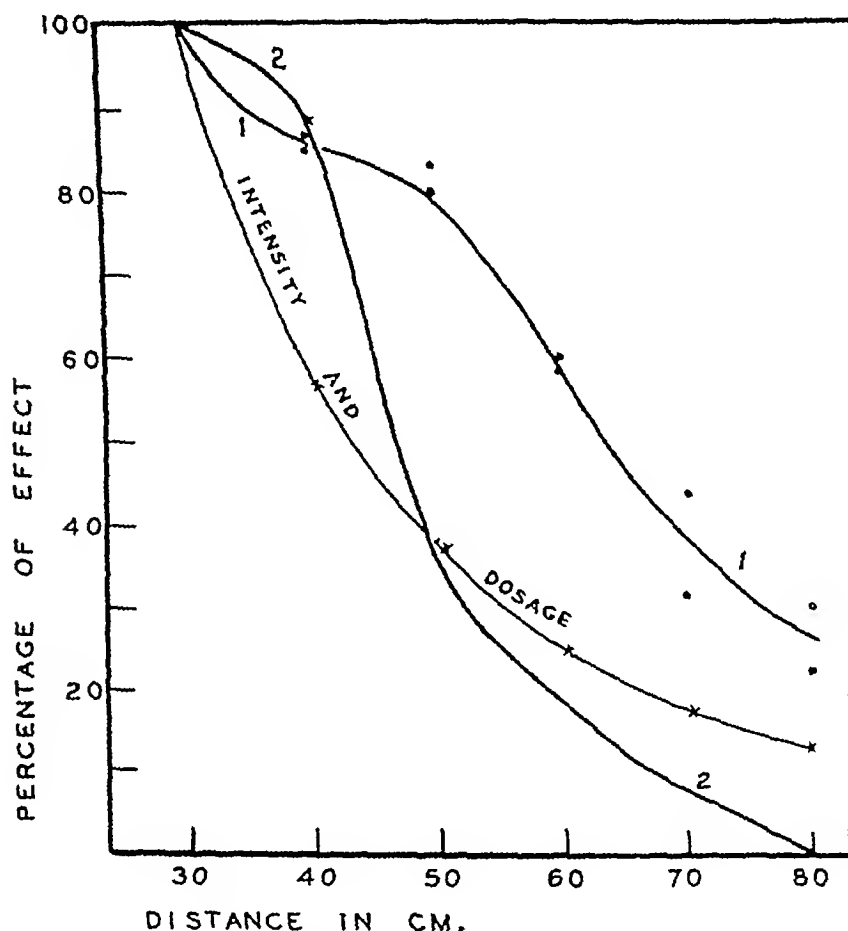


Fig 2 A graph showing the results of experiments similar to those of Figure 1, except that eggs of *M. bivittatus* were employed. Curve 1 is for one day eggs, and Curve 2 is for eggs six days of age.

theoretical is still more pronounced. This difference indicates that the character of the biologic test material is a factor in determining the effect of varying the distance. All of the cells of the one-day eggs are totipotent, and eggs vary widely in sensitivity. This might account for the variation between Curves 1 and 2. The eggs of Curve 2 are more differentiated and have to some extent lost the power of regulation. The range of effective dosages is more restricted, and as the dosage is decreased by increasing the distance the effect falls off very rapidly.

different species. Experiments similar to the above were run with eggs of a closely related species, *M. bivittatus*. The graphs in Figure 2 show the results of these experiments. Curve 1 is of one-day eggs, and the line connecting the highest with the lowest percentage of effect is more nearly straight than that of the actual dosage. This is due, no doubt, to the wide range of effective dosages. Curve 2 is of six day eggs and the sigmoid curve is indicative of a biologic population which is homogeneous in radio-sensitivity. In other words, with the older, more differentiated embryos it requires a

distances tested, and 50 eggs were used for each single experiment. The eggs were examined at the time of diapause (21 days

either totally or not at all affected. It will be noted that the biologic curve approximates or parallels the theoretical one from

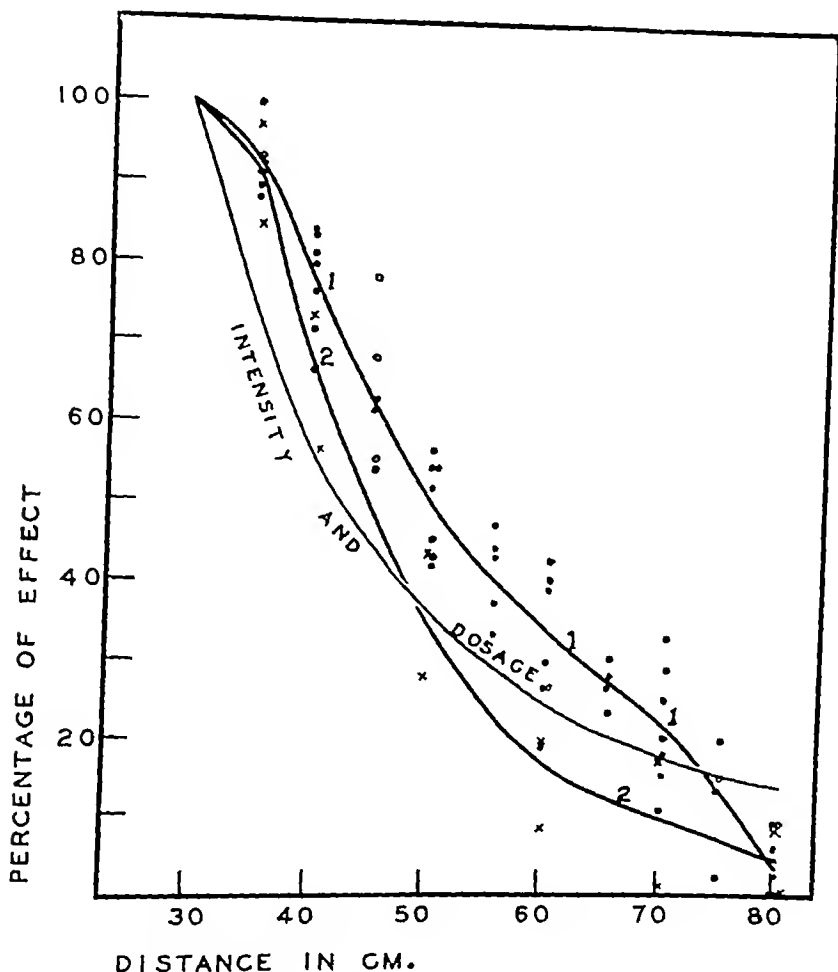


Fig 1 A graph showing the effects on the intensity and on the percentage of biologic effect of increasing the distance. The abscissas indicate the distance in cm and the ordinates show the percentage of biologic effect. The number of eggs injured at 30 cm has been considered as 100 per cent. The intensity at 30 cm was 200 roentgens per minute. The time of exposure was one and one half minutes making the dosage 300 r at 30 cm. Curve 1 drawn through the circles gives the results of irradiating one to two-day-old eggs. The results of similar experiments on five to six-day eggs are shown by Curve 2, which is drawn through the crosses.

at 25° C) when the embryos were developmentally inactive. If an embryo exhibited any injury or defect, no matter how small, it was considered as affected and the "percentage of effect" as shown on the ordinates is an indication of the number of eggs affected but does not represent the extent of injury per individual. In Curve 1 this is not a factor, as the one-day eggs are

40 cm to about 65 cm, but at the extremes the curves differ. In other words, it indicates that if the change in distance is small, the change in biologic effect is relatively less, and if the change in distance is extreme then the loss in biologic effect is greater than predicted by the inverse square law.

Curve No 2 represents the average

higher dosage before any eggs are affected and then, as the dosage is slightly increased, the number affected quickly reaches the maximum. That with extreme changes in distance the corresponding change in biologic effect is much greater. The slope of the biologic

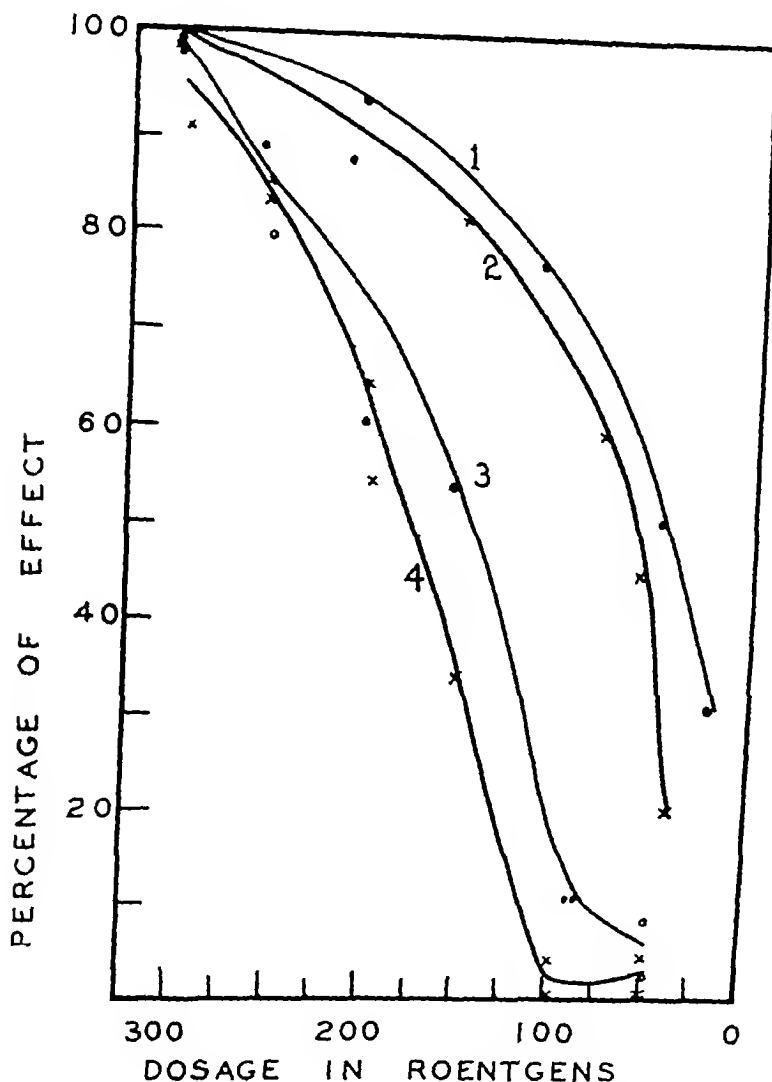


Fig 3 Graphic presentation of experiments in which the dosage was decreased by different means. Curve 1 indicates the response of one day-old *M. bivittatus* eggs when the dosage was decreased by decreasing the exposure time. Curve 2 is for similar eggs but the dosage was decreased by increasing the distance. Curve 3 is for *M. bivittatus* eggs six days of age, and the dosage was decreased by shortening the exposure time. Curve 4 is for similar eggs and the dosage was decreased by increasing the distance.

maximum. These experiments indicate that the inverse square law seems in general to hold where the population is fairly homogeneous, but that the biologic effect does not fall off so rapidly as does the dosage with small increases in distance, and

curve varies with the susceptibility and homogeneity of the population.

The next experiments were designed to study some of the factors involved in the explanation of the variation from that of the inverse square law. One of the first

things to be considered was the sensitivity of the biologic response. This was done by comparing the percentage of effect when

30 cm (Curve 3) than at 70 or 80 cm (Curve 4) in experiments on six-day eggs. This is an indication that susceptibility to

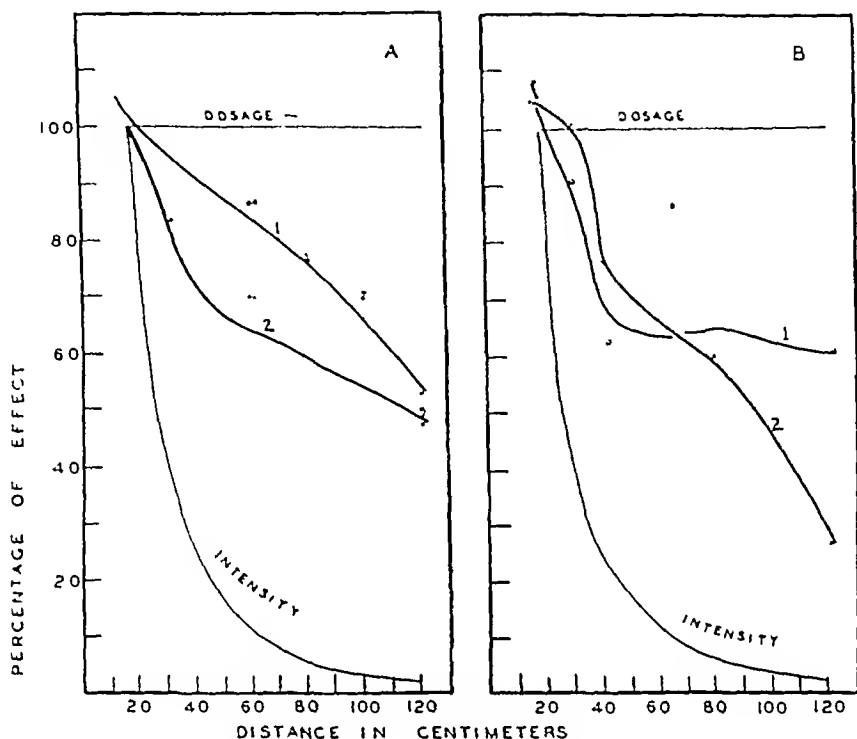


Fig. 4. Two graphs showing the effects of changing the intensity of irradiation by increasing the distance. Graph A is for experiments with *M. differentialis*. The dosage was kept constant by increasing the exposure time while the distance was increased. Curve 1 is for one to two day eggs, Curve 2 is for five to six-day eggs. Graph B is of similar experiments in which *M. bivittatus* eggs were used. Curve 1 is for one-day eggs and Curve 2 is for six day eggs.

the dosage was decreased in two different ways. The first method was to decrease the exposure time, and the second was to increase the distance. The initial time was kept constant in both cases, and the effects of similar dosages were compared. Figure 3 is a graphic representation of the results of such experiments on *M. bivittatus* eggs. Curve 1 is for one-day eggs in which the dosage was decreased by shortening the exposure time. Curve 2 is for similar eggs in which the dosage was decreased by proper increases of distance. It will be noted that the decrease in effect due to increasing the distance was greater than that due to decreasing the exposure time. A certain dosage was also more effective at

total dosage is not *per se* the only factor in the determination of the biologic effect.

The remaining factor to be accounted for is that of intensity, and the foregoing experiments have indicated the strong possibility of its being important. The change in intensity in the preceding experiments was not very large, so it was decided to increase this variation in order to magnify the appearance of the intensity factor. The greatest intensity employed was 575 r/m (17 cm), and the lowest was 11 r/m (120 cm). Figure 4 shows the results of the experiments on intensity. In these experiments the total dosage was kept constant and only the intensity and exposure time varied. Graph A of Figure 4 gives the

results of the experiments with *M. differentialis* eggs, and Graph B is for *M. bivittatus*. Curve 1 in each case is for one-day eggs, and Curve 2 is for six-day eggs. It is evident in all four types of experiments that intensity is a factor, and that the biologic effect changes as the intensity is decreased, even though the exposure time be increased enough to make the total dosage the same.

It is also evident that there is considerable variation in actual values, but there is a tendency which indicates that with a larger number of experiments the decrease in effect due to decreased intensity would approach a straight line, or establish a constant.

As soon as it became evident that intensity is a factor, the question arose as to whether or not intensity is a factor *per se* or whether the decrease in effect is due to recovery during the prolonged exposure. Nine experiments of 50 eggs to each lot have been performed in an attempt to answer this question in a preliminary manner, and the results are tabulated below.

High intensity, short exposure, averaged 87 per cent affected at 200 r

Low intensity, long exposure (22 min.), 57 per cent affected at 200 r

High intensity, long interval (22 min.) between the two halves of the irradiation, 76 per cent affected at 200 r

Thus it is evident that possibly some of the effect is due to recovery, and part is due to the low intensity as such.

DISCUSSION

The first factor which the writers found to alter the biologic curve from that of the theoretical is the character of the test material. This factor has already been recognized by Henshaw and Francis (7) in their investigation of the biologic effects of roentgen irradiation at different depths of a paraffin phantom. The above authors found that not only were the biologic measurements different from the ionization measurements but the biologic measurements differed among themselves at different depths.

The other factor which has been noted in

the present study is intensity. Roesler and Henshaw (10) were able to demonstrate a biologic difference in the effect of radiation delivered at 13 roentgens per minute, as compared with 234 r/m. *Drosophila* was the test material used. Packard (9) had previously found intensity not to be a factor, but his intensities varied only in the ratio of 1:4, whereas Roesler and Henshaw used a ratio of 1:18. Koidsumi (8) found in *Dacus* that intensity was not a factor and that the Bunsen-Roscoe law held, but he also used a ratio of only 1:4. In the present experiments on grasshopper eggs a definite decrease in biologic effect has been found as the intensity is lowered. When the intensity was decreased more than 50 per cent, loss in biologic effect has been recorded. The preliminary experiments on divided dosages indicate that recovery will not account for all of the apparent effects of decreasing intensity. This finding has a substantiation in a more fundamental reaction such as noted in experiments on effects of radiations on chemical reactions by Fricke (6), who found intensity to be a factor *per se* in the decomposition of hydrogen peroxide.

CONCLUSIONS

Developing eggs of the grasshopper have been irradiated at different distances for a constant time exposure, and in some experiments the effect appears to fall off according to the inverse square law. The following factors have been found to modify the biologic curve from that of the theoretical:

- (1) The effectiveness of the dosage at the shortest distance
- (2) Developmental stage of biologic test material, and the way in which the material responds to changes in amount of radiation
- (3) Intensity *per se*
- (4) Low intensities where time allows some recovery or enough development to make the organisms more resistant

The authors wish to express their ap-

preciation to Prof J H Bodine for his counsel and suggestions

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM¹

(Second Series, Second Installment)

By I S TROSTLER, M D , F A C R , F A C P , Chicago

A DISLOCATED SHOULDER AND WHAT CAME OF IT

THE writer one of the most damnable attempts to throw the blame for malpractice upon an innocent man came up not long ago. The particulars are as follows:

A big "roughneck" in a midwestern city sustained a dislocation of the humeral head. He went to a competent, highly respected physician and surgeon, who, after having roentgen examination made, reduced the dislocation and had another roentgenogram made. A few days later the patient reappeared with a recurrence of the dislocation which was again reduced, and another roentgenogram made.

Several days later this patient appeared in a large city, where under an anesthetic in a hospital, a "big-town Doctor" placed his foot in the patient's axilla and tried (but failed) to reduce the dislocation. This Doctor testified that he pulled until he heard "something pop."

Within a few days, the patient was subjected to an open operation in another hospital in the city. After the lapse of considerable time, during which the shoulder was slow in healing, the city doctors informed the patient that, because of improper treatment by his home-town physician, the shoulder would not heal for a long time—if ever.

After all this, the patient brought a malpractice suit for \$50,000 damages against the first physician. At the first trial, one of the men who operated on the shoulder testified (making a 500-mile trip for that purpose), and two of the others testified by affidavit. Fortunately, their

testimony did not agree as to the findings, etc., nor as to who did the operating. With that and the real doubt as to the guilt of the good doctor, the jury was unable to agree, and no verdict was brought in.

After the lapse of about a year and a half, the case was set for retrial, and during the preparation of the defendant's case, my name was mentioned as being one who possibly might help. After a brief correspondence during which I learned much about the case, the attorney for the defendant brought the films in the case to my office in Chicago, and after studying them and listening to the entire story, including the testimony of the city physicians, I made the following analysis of the situation. The defendant had twice successfully and correctly reduced the dislocation and had films to prove same. The first city physician who had put his foot in the plaintiff's axilla and "pulled until something popped," had fractured the humeral tuberosity, and the surgeons who performed the open operation had injured the rim of the glenoid fossa with the "Lane skid," which they testified as having used to get the head of the humerus into the fossa. And, what was apparently more to the point, these men, realizing what they had done, felt it incumbent to hide their own culpability, and to throw the blame upon the defendant in the suit. This was all brought out by reading between the lines of the affidavits and the testimony of the city physicians and was *verified by the roentgenograms*, of which there were plenty.

In the meantime, the two-year limitation of the statute in the city had lapsed, so that at the time of the second trial the city physicians had no more fear of suit against them. Consequently, *they* lost in-

¹ The Editor desires to state that much of the matter herein because quotations of court proceedings has to be printed in form as received without normal punctuation or phrasing.

terest in the case, and none of them testified at the second trial. However, their testimony of the previous trial was admitted at this (second) trial. It was arranged that I was to attend the second trial, and when it came up I appeared as an expert witness. I testified that the films made after the first two dislocations showed the head of the humerus to be in its proper and natural place and that no fractures were present, that the films made in the city showed dislocation of the head of the humerus and fractures of the greater tuberosity of the humerus and of the rim of the glenoid fossa. Much of my testimony was given while examining the films in a stereoscope—which I had requested be brought into the courtroom—and explaining the stereoroentgenograms to each of the twelve jurors individually, as they viewed them in the stereoscope. This consumed much time, but it was time well spent.

It was immediately evident that my testimony created intense interest in the minds of those present. The jurymen sat on the edges of their chairs much of the time, and interestedly came, one by one, to the witness box to have the films explained to them. During the recesses the court reporter, the judge, the plaintiff and his wife, as well as one of the plaintiff's attorneys, asked me to show and explain the films in the stereoscope. *I explained some of the films eighteen times.*

I had been warned that the principal attorney for the plaintiff was decidedly tough and inclined to grill opposing witnesses and naturally expected to receive rather severe treatment from him, but in this I was pleasantly disappointed. After a few sallies, during which he discovered that apparently he would not get very far with the old-timer, he merely tried to belittle the effect of my testimony by repeatedly stressing that I had appeared many times as a witness and that I expected to be paid for my services. In reply to a question as to whether I expected to be paid, I replied, "Certainly, I expect to be paid, just the same as you expect to be paid for coming here and trying this case." This slowed

his curves for a bit, and he subsequently lost control of the ball—in baseball parlance.

The jury brought in a verdict for the defendant physician, and when a new trial was later asked for, the judge refused it. The time to take an appeal to the State Supreme Court had expired. The case may still be taken up on a writ of error, but this is not at all likely to be done.

This was one of my most gratifying appearances as a witness, mainly because it helped in the vindication of a fine, high type, ethical gentleman and proved that right will prevail, at least once in a while.

EXHIBITION OF AMPUTATION STUMP

Several years ago I received from a colleague in a distant State a letter which read as follows:

"I am vitally interested in a personal injury case and would like some of your valuable advice. A younger brother of mine had a serious accident about a year ago, the end-result of which was the loss of his left foot above the ankle. On account of his refusal to accept a ridiculously small sum in settlement he sued the building contractor who was responsible for the accident which caused the injury.

"At the trial my brother's attorney directed him to show his amputation stump to the jury, but the attorney for the contractor objected to this, and the judge before whom the case was tried sustained the objection. That same afternoon, my brother tried to introduce a photograph of his stump, but this was also objected to and ruled out. The jury brought in a verdict for my brother but fixed the damages at so small an amount that a new trial was immediately asked for. This was denied. Now my brother's attorney has appealed the case to our Court of Appeals, and knowing that you have had a world of experience, I am asking you to give me—for my brother—such comment and advice as you can."

After a few days I wrote as follows: "Replying to your letter relative to your brother's case, will say that I have had no

experience in that line, but after interviewing two friends in the legal profession who owed me something of that sort, I was informed that the rule regarding the display or exhibition of injured limbs or members to the jury in personal injury cases is considered to be founded upon good reason and is consequently generally permitted. This is because exhibition of amputation stumps and of the amputated parts are the best means of showing the actual character and extent of the maiming of the individual involved. Of course, if the exhibition would necessitate any indecent exposure or exposure of the private or sexual parts, it would not be permissible. I was informed by both the attorneys questioned that it is preferable and considered best for justice between the litigants that the court order an inspection and it is within the discretion of the court to either allow or to order such an exhibition or inspection. Both of my informants asserted that any objection on the ground that such an exhibition had a marked tendency to excite and/or elicit the sympathies of the jury is not tenable.

"They said this because they thought that that must have been the cause of the objection raised by the contractor's attorney and sustained by the judge. The exhibition of a stump in cases in which an amputation has been done is entirely different from allowing a lamed person to limp or display how badly crippled he is before the jury, because it is so evident that a limp or lameness may be and often is assumed, added to, or exaggerated.

"In *Willis vs City of Browning*, 161 Mo App R, 461, 143 S W R 516, it was held proper for the plaintiff to exhibit her injured ankle to the jury, but that it was error to show how she could walk upon the foot.

"Likewise, in *Newport News and M V Ry Co vs Carrol*, 31 S W R 132, a Kentucky case, and more recently in *Ford vs Providence Coal Co*, 124 Ky R, 99 S W R 609, the exhibition of injured limbs was ruled to be proper. In fact, the decision in the latter case specifically states that such exhibition is the best obtainable evi-

dence of the extent and character of the injury and results thereof.

"Again, in an Appellate Court case in Illinois, *Johnson vs Wasson Coal Company*, 173 Ill App R 414, the plaintiff exhibited his injured ankle to the jury but was not permitted to show how much or little motion he had in the ankle joint.

"I believe that numerous other cases can be found, but doubt if more will be necessary. I am sure that your brother's attorney will be able to secure a reversal by your Court of Appeals and a rehearing on the points claimed," etc.

The Court of Appeals held that the refusal to allow the exhibition of plaintiff's amputation stump was error and remanded the case for a new trial, but before the case came up again the defendants settled by payment of an amount satisfactory to the plaintiff.

A HUNDRED THOUSAND DOLLAR DAMAGE SUIT

Not many radiologists rate high enough in Bradstreet's or Dun's commercial agencies to warrant even a suspicion that they might be sued for a \$100,000. In fact, I know of but one who belongs to that group, therefore, the following tale.

In the Spring of 1929 I was visited by a well-known radiologist in search of advice relative to a malpractice suit in which that amount was being asked as damages, and in which he was the defendant. X-ray treatment had been administered to relieve a pruritus ani in a man prominent in public life. The immediate results were apparently good as the pruritus was promptly relieved. The trouble recurred about one year later, and four more applications of x-rays were administered followed by a remission of the itching.

About one and one-half years later, this patient (plaintiff) alleged that he developed a dermatitis around the anus in the treated area, which became so bad that he had to be operated on and treated surgically for relief. For his suffering, injury, etc., he brought suit against the physician for the aforementioned amount.

The plaintiff was active in his State and in national politics and had made trips to different portions of the eastern United States. As he had admitted that he had had x-ray treatment elsewhere, it was thought likely that this treatment had been received in some of the places in which he had visited during these peregrinations. So that we might locate where the plaintiff did receive these treatments, it became my duty to write to over forty roentgenologists who seemed to be the most likely ones from whom this man might have received treatment, but no record could be found of his having any treatment, except the application of mercurochrome by a New York hotel physician, and of the recommendation and probable use of orthoform, by a well-known Chicago neurologist.

In the meantime—in order to as nearly as possible plan a defense—the writer wrote to two well-known roentgenologists, giving them the particulars of an hypothetical case, with the idea of arranging for them to appear as expert witnesses. This letter was as follows:

"I want to discuss an hypothetical case with you, and get your replies to an hypothetical question relative thereto.

"Given a patient, a man of 40 to 45 years, large, heavy (but you do not need to know that he is a blond), treated for pruritus ani as follows:

"Feb. 27, 1924—30 minutes, 4 ma, 20 in F S D, 0.75 mm Cu and 1 mm Al filters, 180 kv p.

"Same day—15 minutes, 4 ma, 12 in F S D, 0.25 mm Cu, and 1 mm Al filters, 130 kv p.

"Mar. 4, 1924—identically the same dosage as on Feb. 27.

"Patient was markedly relieved.

"Apr. 4, 1925—30 minutes, 4 ma, 20 in F S D, 0.75 mm Cu, and 1 mm Al filters, 180 kv p.

"Apr. 8, 1925—20 minutes, 4 ma, 12 in F S D, 0.25 mm Cu and 1 mm Al filters, 130 kv p.

"Apr. 14, 1925—10 minutes, same F S D, filters, and voltage.

"Apr. 26, 1925—25 minutes, all other elements of dosage the same as last two.

"This was followed by complete relief from the itching.

"The above figures are what you are to consider. Now then, is the above described dosage excessive? Is it within the limits of safety? Would you hesitate to apply that amount of radiation under those circumstances?"

"Let your replies to the above questions be based upon the facts that the apparatus used by the man giving the above described treatments had been charted by Dr. Albert Bachem, and later by Dr. Arthur Erskine, as delivering a full dose with the 180 kv p voltage as above described in three hours.

"Incidentally, it might be of interest to suppose that one and one-half years after the last named date, this patient showed what appeared to be a third degree roentgen dermatitis around the anal opening. In the advent of this, would you not think it altogether likely that the patient had had some x-ray treatment *after the dates mentioned above*? And if the patient admitted to the physician now treating him for the dermatitis that he had had treatment elsewhere, but was still suing the original man for \$100,000 damages, would you be willing to testify in the case, in defense of the doctor?"

"Understand me, all this is regarding an hypothetical case and does not in any way refer to any particular individual, time, place, or thing, and is under no circumstances ever to be connected with any case or suit that you might ever hear of in the future or have heard of in the past."

Within a few days, one of the men to whom the foregoing was addressed replied as follows: "In answer to your question, 'Is the above dosage excessive?' will say, (a) On a basis of an erythema reaction, I would state that the two applications administered February 27, I would conservatively estimate as being less than half the ordinary erythema dose, and this is likewise true of the two applications administered on March 4, at, respectively, 180 and 130 kv p. This would suggest that the total treatments administered April 4, 8, 14, and 26, 1925, appear to be less than the equivalent of one and one-half erythemata if administered at one time, but since these

four applications were administered over a period of more than three weeks, careful calculation might estimate that the total skin effect would not show an erythematous reaction, provided, of course, all of the factors mentioned as to the three hours' time required to produce an erythema with the 180 kv p is reasonably correct

"I take into consideration the fact that the two series of treatments were administered one year apart, with special reference to the last mentioned dosage

"(b) It is reasonable to presume that the above treatments would not produce a third degree dermatitis one and one-half years after their administration. This is especially true in view of the fact that there was no evidence of a marked reaction following the initial treatments in three, six, or eight weeks. It does not seem reasonable that medication following x-ray treatments could produce such a change in one and one-half years, but it is most acceptable to presume that additional radiation therapy had been applied. Employing soft or even penetrating radiation therapy, it might produce in part, at least, the third degree roentgen dermatitis mentioned

"(c) The question of whether this type of treatment of high voltage for pruritis is preferable might be open to argument

"However, the facts in this case do not indicate that even the dosage administered in 1924 and 1925 could produce such a delayed reaction in the location mentioned. We do occasionally see delayed fat necrosis. Personally, I have never observed the latter in any of my cases. Perhaps others have, after the patients have left my service

"(d) Most assuredly I would be willing to testify in this case in defense of the Doctor even without a further careful check-up, since I realize that a third degree dermatitis could hardly follow the above treatment, even though a more careful analysis of the dosage may show that my figures are far too conservative

"I would like to check this over more carefully. Whether or not the patient had subsequent x-ray treatment would not in-

fluence me in being unwilling to do my bit. Of course, if this is the case, it does make the defense a much simpler one. I have only a few days left at my own disposal and therefore hurriedly send you the above very superficial analysis. As soon as I return, I will go over these figures more thoroughly, and if I find any change in my deductions, will let you know."

A short time later, the other man wrote "I have finally got measurements enough made to answer your hypothetical question. The enclosure gives the actual data. The doses are pretty high and the case should probably be settled. The last treatment was the wagonload of straws

"If the case has to be fought, I would, of course, be willing to testify, and I have no doubt that further measurements (under office, instead of laboratory, conditions) would show the dosage to be considerably less."

The enclosure mentioned above quoted the technic given in my letter to him and the following, "Assuming the correctness of the data given and further assuming the size of the field treated to be 10×10 cm, and the tube to be of at least the average efficiency, actual measurement shows that the skin would receive, including backscatter, 6.5 r/minute with the 180 kv technic and 17.5 r/minute with the 130 kv technic

The doses in r-units would, therefore, be as follows

2/27/24	30 × 6.5 equals	195 r
2/27/24	15 × 17.5 "	262.5 r
3/ 4/24	30 × 6.5 "	195 r
3/ 4/24	15 × 17.5 "	262.5 r

Total		915 r
4/ 4/25	30 × 6.5 equals	195 r
4/ 8/25	30 × 17.5 "	350 r
4/14/25	20 × 17.5 "	175 r
4/26/25	25 × 17.5 "	437.5 r
Total		1157.5 r

"Conclusions. The 1924 dosage is certainly safe even if applied at one sitting. The 1925 dose is around the upper limit of safety (if one disregards the Pfahler curve)

If we admit the accuracy of the Pfahler curve (which after all is theoretical), the 1925 dosage need not be considered as a single dose and would be within the limit of safety. The judgement shown in giving 437.5 r at the end of the series is questionable."

In the meantime I had received the preliminary affidavits of both parties to the suit and wrote the attorney for one of the insurance companies—of the defendant—as follows:

"*In re — vs —* No 08487 After reviewing the affidavits of the principal parties to the above captioned case, and what was told me by the defendant, and what I can learn from other sources, I will give you my reaction and ruminations regarding same.

"While it is possibly immaterial, defendant told me that he had never presented a bill, nor received any payment for the treatments involved in this case.

"The application of mercurochrome by Dr. M. in the C Hotel, in New York City after the hunting trip, as per plaintiff's statement, is bad treatment if an x-ray dermatitis (so-called x-ray burn) is present.

"The mixing up and attempt at implicating the tonsil operation at the P Hospital in Chicago, and the hemorrhoid operation in M, O., is only an effort to throw the blame for these upon the defendant. These operations, and the cause for their being done, are separate and distinct entities, as much so as if he (plaintiff) had acquired a fracture and had to have an operation to cure that. They bear absolutely no relation to the pruritus. Pruritus frequently accompanies hemorrhoids or it (pruritus) may occur as an independent and distinct condition, requiring separate and distinct treatment. Also, the sciatica is a separate and distinct entity, probably depending in a measure upon the diseased tonsils, but having absolutely nothing to do with the pruritus or the x-ray treatment, *except possibly to show a deranged general nervous system*.

"Orthoform, as recommended by Dr. S (who is one of Chicago's leading neurolo-

gists), is bad for roentgen dermatitis—so-called x-ray burns. The dermatitis mentioned as occurring after the use of orthoform could not by any stretch of imagination have anything to do with the x-ray treatments or the roentgen dermatitis. That was probably the direct result of the application of the orthoform, and here again indicating an *unusual skin*, which may be used in defense of the presence of roentgen dermatitis.

"In defendant's deposition, the dates are not the same he gave to me while reading from what he said was his original record, nor are the figures of the voltage used the same as he gave to me. He gave 200 kilovolts (which means 200,000 volts) in the affidavit, but to me he gave 180 kilovolts and his record so read. Also, in his original record (as read to me by him in my office), the secondary treatment was 130 kilovolts (130,000 volts) while in the affidavit it was 150 kilovolts. For your information I will give you what his record stated (as read to me by defendant), and from which I have had to figure and ask the opinions of others:

"Feb. 27, 1924—30 minutes, 4 milliamperes, 180 kilovolts, 20 inches, 0.75 copper, 1 Al.

"Same day—15 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.

"March 4, 1924—identically the same doses, with relief from the itching.

"Apr. 2, 1925—30 minutes, 4 milliamperes, 180 kilovolts, 20 inches, 0.75 copper, 1 mm Al.

"Apr. 8, 1925—20 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.

"Apr. 14, 1925—10 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al.

"Apr. 26, 1925—25 minutes, 4 milliamperes, 130 kilovolts, 12 inches, 0.25 copper, 1 Al."

"Aside from the discrepancies between what Dr. T showed me as his figures and the affidavit, in which he admits having given considerably larger doses and the admission to the plaintiff that he had burned him, there is little for me to discuss or comment upon at this time.

"It is not generally considered to be good practice to use as high a voltage as 200 kv or even 180 kv in the treatment of pruritus, and I very much doubt if you will be

able to find any roentgenologist of standing who will admit that he considers it good practice. However, the amount of x-rays applied to the plaintiff, at the times and under the circumstances and conditions given to me by Dr T, from his original record, is not in my opinion and in the opinions of Dr B of St L, and Dr Y, of C, R, sufficient to produce the effect that plaintiff apparently has or had.

"Of course, if it is possible to find that plaintiff had x-ray treatments elsewhere, that will help the case enormously. Or if, as Dr T told me, the plaintiff told Dr F (who operated upon him) that he had had some x-ray treatments elsewhere, and that evidence can be used, and not barred as privileged, that may and doubtlessly will help a lot. To me the fact that defendant gave me figures from his original record, and in his affidavit gave figures indicating that he gave *more* x-rays, is inexplicable. If he did one thing, *he did that*, and because he gave two different sets of figures, he weakened his case, *certainly to me*. Knowing him, as I do, to be decidedly more than usually precise and accurate in matters of this sort, I cannot help be just a bit vexed with him.

"As regards the use of the ultra-violet light, following after and upon a roentgen dermatitis, the medical profession is not at all agreed. Up to about two years ago, it was believed that it was good practice, by some pretty well informed men. Sampson advocated it in 1922 and stressed it in his book, which was published in 1924, and Greer, Swanberg, and Rulison were pretty strong advocates of the use of the ultra-violet light under these conditions. Personally, I never put any stock in it, and later my contention was borne out by actual experiments and proven, by such high class investigators as MacKee, Pfahler, and others. Tests made by these men were reported to make the skin more sensitive, by applying the ultra-violet light.

"Judging from the testimony given by the plaintiff, in his affidavit, it is apparent that he did have a mild x-ray dermatitis, and it is on the basis of this and the use of

the 200 kilovolt technic, that Dr B, of this city, was going to give the plaintiff an affidavit that the technic used by the defendant was not good practice. However, after a short talk with me, the Doctor decided not to give defendant any sort of testimony. Evidently they (defendant's attorneys) are here trying to secure testimony that the technic was bad. Of course if I hear about it in time, I can help in that regard.

"I advised Dr T to get in touch with attorney D, of I C, who is, in my opinion, one of the best men I know to defend a case of this sort. I also advised him to secure a number of high class expert witnesses and suggested the names of five well known men to him, besides the names of Messrs Bachem and Darnell as physicists.

"I believe that I told you that I have letters from the two men replying to my hypothetical questions relative to a parallel case to this, in which they both give as their opinions that the dosage as given by Dr T (to me) would not under normal conditions produce a 'burn,' and that they were ready to so testify, but I do not know what they will say regarding the dosage as given by defendant in his affidavit.

"Of course, much depends upon what can be developed from the information that can be secured from the G Hospital in W. Defendant has written to a man there to look up that material.

"Also, most vigorous efforts must be made to exclude the doctrine of *res ipsa loquitur* being applied in connection with this case. I do not know how the courts in that State hold in that regard. It may be possible to use the recent Iowa case there. I refer to the *Whitmore vs Herrick*, (218 N W R, 335) case. I was out there at the trial, and felt that I helped win it. *Res ipsa loquitur* was barred and the verdict of the trial court was upheld by the Iowa Supreme Court. Also *McCoy vs Buck*, an Indiana case (157 N E R, 456), where this same doctrine was denied, may help some.

"If we are unable to secure or present any evidence that defendant did receive x-ray treatment elsewhere, I am of the

opinion that it will be very desirable to show by witnesses that the machine had been recently calibrated, and this can be done by two competent men, according to what Dr T told me. It will, of course, be advisable to prove by an overwhelming amount of expert testimony that the dosage given by the defendant was not excessive. I am a native of that State, having lived there for something like thirty-eight years and know the minds of the people out there pretty well. The city where the trial will occur is a University town, where higher education is highly thought of and given high standing and credence. A jury will listen to and give full weight to the testimony of experts who can qualify to the limit, and as this is a case for experts, I advise that plenty of expert testimony be presented. I say get plenty, get good ones, and use them to the limit. Hammer home that sort of testimony repeatedly, reiterating again and again that the dosage was correct, that it should not have done damage, etc., and you will have a chance to win this case."

The next day, I wrote defendant as follows: "My Dear R, when I read your deposition, submitted to me by the insurance company, I was disappointed. Why did you admit that you used 200 kv when your record showed (when you were here) that you used 180 kv? And 150 instead of 130 kv? I know that there is no use howling now, so suppose we let it rest as you testified, but it is really too bad, because that may make a big difference in the outcome of the entire affair."

"I am sending you herewith a carbon copy of my letter of yesterday to the insurance company, which contains some things that may have quite a bearing upon how best to fight this case. They (the insurance company) usually have me write them such a letter, at the beginning of the litigation regarding x-ray dermatitis cases, and evidently have found it worth while to do so, as they continue to have me do it. You, of course, understand that anything I say therein has absolutely no personal bearing, and is absolutely confidential.

They will see that your attorneys get a copy of my letter."

"In the letter to the insurance company, you will notice a casual mention of Dr B. I do not know just why I did it, but last Thursday before the meeting of the Chicago Roentgen Society, I asked him if he had heard about your case. He spoke up with 'Yes, did they come to see you too?' When I asked him who he meant by 'they,' he told me that a firm of lawyers here had brought a copy of your affidavit to him and wanted him to make an affidavit that the technique used by you was wrong, and not according to the usual and most approved practice, etc. After calling his attention to the particulars in this case and some connected incidents he decided that he would have nothing to do with the entire matter. Evidently the plaintiff's local attorneys are after testimony and while I have good reason to believe that almost anyone except X would call me before doing anything, I would not be surprised if they got some one (or more) to give or sell them what they want, particularly as they are prepared to pay for it. Of course, if I get at the men first, they will think twice before doing it, but I may not get at them."

"I have yours relative to what you have done regarding the G Hospital in W, and think that your way of doing it is best. Let me know as soon as you have a reply, and in the meantime try to get F to remember where defendant said he received the other treatment."

"Trusting that you will come out of this mess with colors flying, even if you do have a few after-pains," etc.

A few days later, after a letter from defendant, I wrote the following: "While I know Dr T by sight, and he probably knows me the same way, I have no speaking acquaintance with him, but I think that it will be easy enough to have your Mr D secure an interview with him. I believe that I can readily arrange that Dr T is an urologist and g-u surgeon, and

"I have been doing some digging in the literature and find quite a few things that have not, as far as I can learn, been injected

into the defense of an x-ray dermatitis case before. Among the new things are

"Syphilis has been known to sensitize the human skin to radiation. So if a patient has syphilis, he may develop roentgen or other radiation reactions more readily than a non-syphilitic

"Porphyrinuria and porphyrinemia, due to taking some of the commonly used synthetic sedatives and sleep producers, produce a lessened sensitivity to radiation. Dr. Rollin H. Stevens, of Detroit, can give you more relative to this subject than any one I know.

"Buckwheat also produces a sensitization to radiation, particularly in individuals of light complexion (your man is a blonde). This is due to the porphyrin content. A Dr. Betz took 0.2 gram of porphyrin in October and suffered a "light stroke" from exposure to ordinary sunlight, the following December.

"Another important fact, which might be important in this case is that porphyrin products in the circulation, in addition to producing a sensitization to light, also cause itching. Sulphonal and luminal produce porphyrinemia and porphyrinuria, with sensitization to light and x-rays.

"The use of ointments and topical applications containing tar are known to sensitize to x-rays, and fluorescent substances like eosin and quinine when used either externally or taken internally, sensitize to the x-rays. Salvarsan and its products also sensitize to light and probably to x-rays.

"I am calling your attention to these items so that you may have them looked up. If they are found to be of any use in the case, get the material into shape to use. As previously stated, Stevens probably knows more about the porphyrin skin sensitization than any man in the country. You will remember him from the Panama trip. I have spoken to him about your case, and he said that he will be glad to do anything within his ability to help."

After considerable further investigation and extensive correspondence, we were unable to find out where the plaintiff in this case received any more x-ray treatment,

although he had told the surgeon who operated upon the damaged region that he had received same. In a great measure because of the prominence of the plaintiff as well as the undesirability of the great notoriety the defendant would receive if the case went to trial, it was deemed advisable to settle out of court and before trial. The case was therefore settled for \$8,700.

PHYSICIAN'S OR TECHNICIAN'S RESPONSIBILITY

The problem as to whether a physician or his technician is responsible for injuries resulting from errors, omissions, or carelessness of the technician, and the consequent application of the law of agency, which in so many words states that the principal is responsible for the acts of his agent, or the law of master and servant, which generally applies in such cases, and involves the maxim "*respondeat superior*," which, liberally interpreted means, *the master is responsible*, comes up frequently in our work.

A radiologist in an eastern State informed me that both he and the hospital where he was employed as roentgenologist were threatened with a malpractice suit because of an alleged injury resulting from a patient receiving an electric shock in the x-ray department, while a technician was preparing to make a roentgen examination of an injured wrist.

He stated that he was practising roentgenology in the hospital, on a part-time basis for a fixed salary, and had assumed that the hospital would be held liable if any malpractice suit were brought.

He asked, "What can you tell me as regards my liability?" I have no malpractice insurance. My reply was necessarily somewhat equivocal because of the vagueness of his information. He was apparently in considerable distress and wanted something, one way or the other, to relieve the doubt or questionable situation, so I immediately replied.

"*Bis dat qui cito dat!*" Replying to yours of last Saturday, will say that your liability depends upon several things,

among which are, whether the technician who was careless and who caused the alleged injury, was *in your employ* or in the employ of your employer, the hospital, whether she was acting as your agent, and you were responsible for her acts or whether she was entirely under the control of the hospital, and you had no responsibility or control over her conduct or acts while in the roentgen department at the time the alleged accident occurred

"If the technician was acting as *your agent*, both you and the hospital may be held liable, while if she was neither your employee nor your agent, it is decidedly unlikely that you will be held responsible. This is particularly true if you were not present when the injury occurred, but that of itself is open to some question and debate

"It is usually considered good logic that physicians do not become responsible for acts of nurses or technicians, when such acts as are brought into question constitute duties usually and normally performed and included in the regular duties of nurses and technicians. This is particularly true if the nurse or technician be not in the employ and under the specific directions of the physician, or in such a situation where the relation of employer and employee or as the law sees it 'master and servant' does not exist. If, as already intimated, the relation of 'master and servant' does exist, the maxim of '*respondeat superior*,' or 'the master is responsible,' applies, if and when the act performed involves some portion of the duties of the employee while acting as such employee

"It has been held by highly respected courts, that when a nurse, while performing the regular duties of her profession, does something or fails to do something which she should have done, the physician in charge of the case may not be held liable. For example, if while administering hypodermic medication a nurse breaks an hypodermic needle, and damage results, the physician who directed that she administer the hypodermic injection is not considered responsible and will not be held liable

This is because the administration of hypodermic injections is a part of the usual and regular duties of the professional nurse. On the other hand, if a lay person, not a licensed or graduate nurse, administers an hypodermic injection pursuant to the instruction or order of a physician and the breaking of a needle causes injury and damage, the physician is, should be, and would be held liable. This is because the person so doing the damage has no legal duty, right, or function as regards the act which caused the injury, and does the act as the agent of the physician, whose duty under the conditions just cited, was to administer the injection himself. The principal is responsible for the acts of his agent. Right here it may as well be stated that a principal may only be held responsible for the acts of his agent, if the acts of the agent are within the proper and authorized duties and acts of the principal. For example, if a veterinary surgeon were to direct that a nurse suture a wound or incision on a human being, the veterinarian would not be liable, provided, of course, he were not a physician for human ailments and ills. Likewise, if a physician directed a nurse to suture a wound, he would be liable for any injury or damage resulting from such act because it is not a part of the usual and regular duties of a nurse to suture wounds, and the nurse when doing such suturing was acting as the agent of the physician

"In *Ragan vs Zimmerman* (206 Calif R , 723, 276 Pac R , 107) a dentist employed a technician to make roentgen examinations. While doing her work one day, a patient received an electric shock and burn. Suit was brought against the dentist, and the trial court gave the plaintiff a verdict and judgment for damages. The case was appealed to the Supreme Court of California (where this occurred) and where the judgment was confirmed, and the dentist had to pay

"*Witherington vs Jennings*, 149 N E R , 221, a Massachusetts case, is to all intents and purposes similar to yours unless I am in error. Dr Jennings was the salaried, part-time roentgenologist in charge of that

department of a hospital Meacham was a technician employed by the hospital Dr Jennings wrote a prescription for certain x-ray treatment to be administered to Mrs Witherington Meacham administered the treatment, but inadvertently left out the filter, with the usual result The patient sued the physician who prescribed the treatment, contending that he was responsible because he was the head of the x-ray department in the hospital

"The trial court decided in favor of the defendant physician, but plaintiff appealed to the Supreme Court of Massachusetts, where the judgment of the lower court was affirmed

"In that decision, the Supreme Court said 'Meacham was not employed by the defendant, he was not the defendant's agent or servant They were fellow employees of the — hospital The defendant was not responsible for the neglect of Meacham in administering the treatment, which was entirely under his control He did not participate in the operation and was not liable for the injury'

"In a North Carolina case (*Covington vs Wyatt*, 145 S E R , 673), where the State law requires that the physician or other person assisting at a birth, instill a silver solution into the eyes of a newly born infant, a graduate nurse employed by the hospital asked the attending physician if she should administer the drops to the baby's eyes Upon being told that she should, she instilled several drops of a 30 per cent solution of silver nitrate, instead of the regulation 1 per cent solution, with terrible results

"The physician was sued for malpractice, and in the trial court a verdict with judgment was given the plaintiff On appeal to the North Carolina Supreme Court, the judgment of the lower court was reversed The latter court held that according to the law, the physician might apply the silver solution or he might direct the nurse to do it The nurse having done it, while acting as an employee of the hospital, and not as the agent of the physician, and because it was a part of the duties of nurses

to instill drops into the eyes, the physician was therefore not liable'

"In another case²— this one in Seattle—a physician directed a nurse to inject ergot hypodermically An abscess resulted and the physician was sued for malpractice The trial court brought in a verdict in favor of the physician defendant The plaintiff appealed the case to the Supreme Court of Washington, where the judgment of the lower court was affirmed, 'because the giving of hypodermic injections, under physician's orders, by hospital nurses is a part of nursing,' and because the nurse was an employee of the hospital and not acting as the physician's agent

"In *Runyan et al vs Goodrum*, an Arkansas case, involving the question of 'master and servant,' the Supreme Court of that State said (Feb 21, 1921), that 'Hospital owners and roentgenologists are not responsible for carelessness of x-ray technicians'

"In *Gross vs Robinson* (218 S W R , 924), a Missouri case, the Supreme Court of that State decided that the rule of '*Respondeat superior*' does not apply I am sure that it will be very much worth your while to have this decision reviewed

"In *Phillips vs Buffalo General Hospital* (146 N E R , 199), a New York case, it was held that the 'hospital is not held responsible for neglect of an orderly'

"I believe that I have given you sufficient references to set your attorneys searching, and probably more than they will want or need"

Recent inquiry from the radiologist to whom the foregoing long letter was written, elicited the following "I had almost entirely forgotten about that threatened malpractice suit when I received your letter a few days ago I am glad to inform you that when the patient consulted his lawyer, and the latter visited me, and I showed him your letter he decided not to take the case and advised the patient not to sue me So he did not sue and we were relieved of a rather disagreeable mess

² *Thompson et ux vs Virginia Mason Hospital et al*, 277 Pac R 69

But I assure you that I now carry malpractice insurance, thanks to your advice "

The fact that this radiologist "had almost forgotten about that threatened malpractice suit," etc., is quite the usual thing. Most of us are far too prone to forget ominous or threatening incidents as soon as they pass.

X-RAY PAPER ARE ROENTGENOGRAMS ON IT ADMISSIBLE IN EVIDENCE?

About two years ago, a roentgenologist in a central State asked me in a letter "if roentgenograms made on x-ray paper could be introduced and properly recognized in legal procedures, or, in other words, would they be admitted in evidence?" I replied:

"While I have not heard that that question has ever been raised, either in court or out of court, it seems to me that it can make no difference legally what kind of substance serves as a supporting medium for the silver emulsion which produces the roentgenogram.

"I can conceive of no good reason why either glass, celluloid, cellophane, cloth, or paper may not be used to support or carry the chemicals which produce the representation of what the roentgen rays portray. It is my impression that it is not the glass, celluloid, paper, or what have you that makes the roentgenogram valuable as a diagnostic medium and as such, useful in evidence to prove certain facts in court. To my notion, and I think that every sensible person will back me up, it is the silver salt, which has been first acted upon by the roentgen rays and then by the chemicals in the dark room that is the all-important element in the roentgenogram.

"Therefore, if my opinion is worth anything, I say unqualifiedly and without reservation that roentgenograms made upon x-ray paper or other photographic paper, should be and would be admitted in evidence just as freely and legally as would any glass or celluloid roentgenograms.

"I have used the paper a few times in cases where they may have to be introduced in court, and if I do introduce them,

I fully expect to have no trouble because they are made on paper.

"In reply to your postscript as regards my personal opinion of the 'paper films,' that is entirely another matter.

"Something like twenty-odd years ago, our late lamented friend, George Brady, brought out his Paragon X-ray Paper, which after a trial of a few months he found was not very well received, and he soon dropped its production. I tried it at that time and like many others advised George to drop it, and stuck to plates until the duplitized films made their appearance. Then more recently some of the manufacturers thought that they had something real good, and they brought out the present line of x-ray paper.

"After trying all the available makes and brands of x-ray paper I am still using celluloid films. It appears to me that the only advantage that any of the papers have is cheapness and because the difference in the prices means at most only a few cents in each case, in view of the undeniable and undisputed facts that the celluloid films give us the maximum detail, as compared to paper and that the transparent character of the celluloid films permits of a more critical and careful study of the finer tissue changes as compared to the translucent paper, I consider the celluloid films decidedly superior and preferable.

"The Minnesota Radiological Society decided against the use of paper in 1934, and at the meeting of the Radiological Society in Memphis in December, 1934, resolutions discouraging the use of x-ray paper were introduced by a Minnesota radiologist, and I believe adopted."

The roentgenologist who asked the question about paper later wrote me that an attorney had told him that he was going to object to the introduction of paper roentgenograms in a case, but who, when shown my letter, informed him that he would not make the objection. The writer is very desirous of learning if any of the readers hereof have found any legal difficulties with paper roentgenograms.

(To be continued)

AN INVESTIGATION OF X-RAY FILMS AND DEVELOPING SOLUTIONS¹

By CHARLES WEYL, S REID WARREN, JR., and DALLETT B O'NEILL,
Philadelphia

From the Moore School X-ray Laboratory, Moore School of Electrical Engineering,
University of Pennsylvania

INTRODUCTION

THE maintenance of a high standard of roentgenographic output depends upon the following general factors

- 1 Calibration and positioning of the patient,
- 2 Characteristics of permanent equipment such as power supply lines and transformers, high voltage generating apparatus, x-ray tube, intensifying screens, cassettes, and viewing apparatus,
- 3 Films and processing materials and methods,
- 4 Roentgenographic technic

The first factor presents a problem which at the present time has not been completely solved. No precise scientific method of determination of the x-ray absorption characteristics of the patient has been perfected for routine clinical application.² This will necessarily result in some variation in the roentgenographic quality, but the magnitude of this variation may be greatly reduced by careful measurement of the thickness of the part being roentgenographed and experienced qualitative estimation of the type of the structure of this part.

The items listed under the second factor

¹ This investigation was conducted at the Moore School of Electrical Engineering, University of Pennsylvania, under a special grant by the Faculty Research Committee of the University of Pennsylvania. The Moore School X-ray Laboratory, in which these tests were made, operates under a grant to the University of Pennsylvania by the National Tuberculosis Association.

- An investigation is being made at the Moore School X-ray Laboratory of a practical, scientific method of determining the x-ray absorption characteristics. It depends primarily upon the comparison between the ionization effects of two identical beams of x-rays, one of which impinges directly upon the ionization chamber, the other of which is intercepted by the patient before traversing the ionization chamber.

are considered as permanent equipment, with reference to films and processing materials which are being replaced almost continuously. Sufficient information concerning these items is available³ to provide a sound basis for their scientific choice. With this equipment installed, calibrated and operated with care and precision, the roentgenographic output will be determined chiefly by the films, processing materials and methods, and the roentgenographic technic employed.

The criteria of the roentgenographic output are the photographic densities of the finished film. Density is that characteristic of an area of exposed and processed film which describes the relation between the intensity I_0 of light incident upon the film to the intensity I_1 of light transmitted through the area. $\text{Density } D = \log_{10} \frac{I_0}{I_1}$, which is a positive pure number. It has been shown⁴ that in general maximum interpretability of a roentgenogram is obtained when the density of the lightest portion of the diagnostic area is no less than 0.4 and the density of the darkest portion of the diagnostic area is no greater than 1.5. Therefore, it is desirable to use films, developing solutions and processing methods, and a roentgenographic technic which will permit the most efficient production of the densities in this range.

The speed of a film or developing solution determines the exposure necessary to produce a given density in the finished film. As the speed increases the exposure neces-

² Charles Weyl and S Reid Warren Jr. Apparatus and Technique for Roentgenography of the Chest. Chap 2. Charles C Thomas 1935.

³ Charles Weyl and S Reid Warren Jr. Apparatus and Technique for Roentgenography of the Chest. page 39. Charles C Thomas 1935.

sary to produce this given density decreases. Consequently it is advantageous to employ a film and developing solution having high speed characteristics. The contrast characteristic determines the difference in the densities produced by exposures having a given ratio.^{*} As the contrast increases the density difference for the given exposure variation also increases. In making a roentgenogram of a patient the variation of exposure over the film is caused by the difference in absorption in the various parts of the patient. Thus the greatest exposure and greatest density are obtained in the shadow of the least absorbing portion, while the least exposure and least density are found in the shadow of that portion which is most highly absorbing. If the ratio between the greatest exposure and the least exposure is held constant and the film contrast or contrast due to developing solution is increased, the resulting density difference increases. However, the exposure ratio depends upon the technic employed. A low x-ray tube voltage and high x-ray tube current technic produces a much greater exposure ratio with the same patient than a high x-ray tube voltage and low x-ray tube current technic. Since it is desired to obtain a roentgenogram having a maximum density of 1.5 and a minimum density of 0.4 in the diagnostic area, this density difference may be obtained with a combination of low contrast characteristics of film and developing solution and a low voltage, high current technic, or with high contrast characteristics and a high voltage, low current technic. But the x-ray tube efficiency increases as the x-ray tube voltage increases. There-

fore, it is desirable to employ a film and developing solution with the greatest possible contrast to permit the use of the highest x-ray tube voltage which will produce the required density difference.

When films and developing solutions having high speed and contrast characteristics have been chosen and correct processing methods adopted, it is possible to establish an optimum roentgenographic technic for any type of roentgenography. The roentgenographic output then should be of the highest possible quality. Of even greater importance, however, is the maintenance of this high standard. Proper maintenance requires

- 1 Careful, precise control of all operations both in the roentgenographic room and in the dark room,
- 2 A thorough and accurate check of all equipment and calibrations at regular intervals,
- 3 A supply of film and of developing solution powders whose speed and contrast characteristics remain constant over reasonable periods of time.

From the above discussion it may be seen that there are many problems involved in the routine production of high quality roentgenograms. Important among these is the choice and correct use of films and developing solutions, and in addition to their inherent importance is the complexity introduced by the continual replacement by fresh supplies.

It is the purpose of this investigation to consider the problems associated with films and developing solutions.

Since the unsharpness caused by grain in any modern brand of film is so slight that it is completely masked by the unsharpness resulting from finite focal spots, intensifying screen crystals and motion of the parts of the patient being roentgenographed, it may be seen that film grain is not a factor in roentgenography. The important criteria in the choice of films and developing solutions are the speed characteristics, contrast characteristics, and the constancy of these characteristics, and of the three criteria the last is probably the

^{*} In the range of densities of interest, i.e. 0.4 to 1.5 the density is approximately proportional to the logarithm of the exposure so that the density difference resulting from exposures A and B is

$$D_A - D_B = K \log A - K \log B = K (\log A - \log B)$$

where K is a constant of proportionality. But

$$\log A - \log B = \log \frac{(A)}{(B)}$$

Therefore

$$D_A - D_B = K \log \frac{(A)}{(B)}$$

Thus the density difference is determined not by the exposure difference but by the exposure ratio

most important. In order to develop simple and accurate methods for the quantitative determination of these criteria, and to investigate processing methods, three makes of film and three brands of developing solution were tested. In Section A below there is described the first part of this investigation, from the results of which optimum processing conditions are determined and some important characteristics of films and developing solutions are observed. From the analysis of the results of Section A methods for determining the desired criteria are devised. In Section B these determinations are made for the three makes of film and the three types of developing solution being tested.

SECTION A

The three makes of film chosen for the investigation are designated A, B, and C and the three makes of developing solution are designated X, Y, and Z. A and X are made by one manufacturer, B and Y by another, and C and Z by a third. It was desired to make identical exposures on a sufficient number of strips of each of A, B, C so that each make of film could be developed in each brand of developing solution under each of the chosen developing conditions. The processing factors which could be varied were

- 1 Concentration of developing solution,
- 2 Temperature of developing solution,
- 3 Time of development

It was decided to vary the developing solution concentration and the time of development. Since the optimum temperature of the developing solution is determined by the nature of the chemical reactions involved it was considered most desirable to use only this optimum value. All developing solutions were stirred thoroughly and frequently to insure homogeneity.

Test Procedure—The roentgenographic exposures were made with a four-valve x-ray apparatus supplying full wave rectified voltage to the x-ray tube. The apparatus had a capacity of 90 kv p, 300 ma, and the x-ray tube was of the 19° line-focus type

with an effective focal spot 5.0 mm × 5.0 mm. The exposures were timed with a synchronous impulse timer. The technic used for all exposures was

- X-ray tube voltage, 80 kv p,
- Average x-ray tube current 100 ma,
- Time of exposure, $\frac{1}{10}$ second,
- Focal spot-film distance, 72 inches

The x-ray tube voltage was measured with a sphere gap and the x-ray tube current was measured with a ballistic milliampere-second meter. The values so obtained, as well as the exposure time, were checked oscillographically.⁶ The oscillographic recordings also checked the constancy of the wave form.

An aluminum ladder was used as the test object for all exposures. The ladder was composed of eight sheets of commercially pure aluminum, each 14 inches in length and $\frac{1}{8}$ inch thick. The widths of these sheets varied in steps of one-half inch from $\frac{1}{2}$ inch to 4 inches. They were arranged to provide a ladder having eight steps varying in thickness by $\frac{1}{8}$ inch, from $\frac{1}{8}$ inch to 1 inch, each step being 14 inches in length and $\frac{1}{2}$ inch wide. In making each exposure a strip of $\frac{1}{8}$ inch thick lead 14 inches long and $\frac{1}{2}$ inch wide was placed beside the ladder and parallel with it to provide for fog measurement. All exposures were made with the same bakelite front cassette in which were mounted a pair of intensifying screens.

Each piece of film to be exposed was cut to a width of 6 inches and a length of 14 inches and placed in the cassette. The aluminum ladder and lead strip were placed in contact with the front of the cassette and the x-ray tube so positioned that the focal spot was on a line perpendicular to the front of the cassette and passing through the center of the aluminum ladder. An exposure was made using the technic described above. The piece of film so exposed was processed, and the densities under each step were carefully measured across the film to check the uniformity of radiation.

⁶ Charles Weyl S. Reid, Warren Jr. and F. Maurice McPhedran, *Methods of Measuring and Recording Roentgen ray Tube Currents and Voltages*. *Am. Jour. Roentgenol. and Rad. Ther.* December 1931 26, 871.

No appreciable density variation could be found under any step within 3 inches of the center of the film. All strips used in this investigation were cut, therefore, from the middle 6 inches of each piece of exposed film.

Three pieces of each make of film were exposed in the manner described above and twelve strips $\frac{1}{2}$ inch in width were cut from the middle 6 inches of each piece of exposed film. In this way there were provided 36 strips, each 6 inches long and $\frac{1}{2}$ inch wide, of each type of film, all identically exposed.

Having decided to vary the developing solution concentration and the time of development, the following values were chosen for use in developing the films

1. Developing solution concentration
 - a. Normal concentration,
 - b. Three-quarters normal concentration,
 - c. One-half normal concentration
2. Time of development
 - a. Three minutes,
 - b. Five minutes,
 - c. Six minutes,
 - d. Eight minutes,

By "normal concentration" is meant the concentration of the solution when prepared in accordance with the instructions of the manufacturer. The developing time normally used in routine processing is from five to six minutes with fresh developer.

One gallon of each of the three makes of developing solution was prepared in accordance with the instructions of the respective manufacturer. Exposed strips of each of the three brands of film were developed in each of the developing solutions for each of the development times at a developing solution temperature of 65°F . This procedure was repeated after diluting the developing solutions to obtain three-quarters normal concentration. After developing at three-quarters normal concentration, the developing solutions were diluted to one-half normal concentration and the developing procedure repeated.

When the strips were completely processed and dried the densities of all the

steps of all strips were measured. The density measurements were made with a comparative photo-electric densitometer.⁷

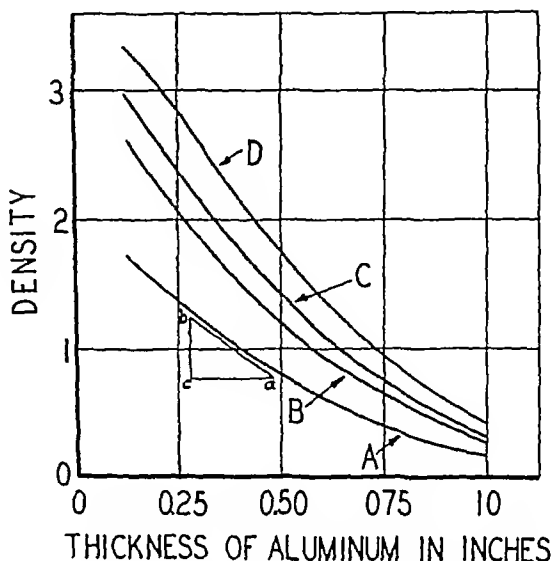


Fig 1. Variation of density with thickness of aluminum. Film C, developing solution Z, normal concentration. Time of development: A, 3 minutes; B, 5 minutes; C, 6 minutes; D, 8 minutes.

Results—For each strip there was plotted a curve of density against thickness of aluminum, similar to those shown in Figure 1. As the thickness of aluminum increases the roentgenographic density decreases because of the increased x-ray absorption of the greater thicknesses. For purposes of comparison it is convenient to define the contrast for a particular thickness of aluminum as the slope of the density curve for that thickness of aluminum. For example, the contrast for $\frac{3}{8}$ inch of aluminum, curve A, Figure 1, is equal to the quantity

(cb) density units
(ca) inches of aluminum = 0.29 density units per $\frac{1}{8}$ inch of aluminum. This definition is consistent with the discussion of contrast in the Introduction if comparisons are always made between contrasts evaluated for the same aluminum thickness. With this definition established, the

⁷ Charles Weyl and S. Reid Warren, Jr., *Apparatus and Technique for Roentgenography of the Chest*, page 112. Charles C. Thomas 1935.

contrast may be obtained for any point on any curve of density against thickness of aluminum

sponding curves for the other makes of film and developing solution have similar form, the data necessary for the purposes of this

APPENDIX 1, TABLE I—DENSITY AND CONTRAST FOR $\frac{3}{8}$ INCH OF ALUMINUM

Film	Develop- ing Solu- tion	Concen- tration	Density				Contrast			
			3	5	6	8	3	5	6	8
			min	min	min	min	min	min	min	min
A	X	1	0.96	1.49	1.80	2.20	0.27	0.36	0.48	0.57
A	X	$\frac{3}{4}$	1.05	1.67	1.91	2.26	0.27	0.37	0.44	0.51
A	X	$\frac{1}{2}$	1.01	1.63	1.87	2.14	0.25	0.39	0.40	0.48
A	Y	1	1.19	1.81	2.10	2.30	0.24	0.47	0.54	0.54
A	Y	$\frac{3}{4}$	1.03	1.62	1.83	2.06	0.23	0.33	0.38	0.41
A	Z	1	1.13	1.80	1.94	2.34	0.28	0.46	0.53	0.57
A	Z	$\frac{1}{2}$	0.99	1.58	1.80	2.18	0.26	0.32	0.38	0.50
B	X	$\frac{3}{4}$	0.82	1.44	1.72	2.20	0.24	0.31	0.40	0.44
B	X	$\frac{1}{2}$	0.75	1.29	1.52	2.03	0.20	0.25	0.31	0.38
B	Y	1	1.04	1.74	2.01	2.43	0.21	0.37	0.42	0.49
B	Y	$\frac{3}{4}$	1.01	1.64	1.87	2.36	0.21	0.32	0.36	0.40
B	Y	$\frac{1}{2}$	0.82	1.38	1.63	2.14	0.19	0.25	0.27	0.33
B	Z	1	1.04	1.56	1.78	2.34	0.20	0.33	0.43	0.54
B	Z	$\frac{3}{4}$	0.89	1.47	1.66	2.11	0.22	0.27	0.30	0.42
B	Z	$\frac{1}{2}$	0.79	1.31	1.55	1.84	0.21	0.25	0.32	0.34
C	X	1	0.86	1.42	1.64	2.05	0.27	0.38	0.49	0.55
C	X	$\frac{3}{4}$	0.97	1.54	1.81	2.15	0.25	0.39	0.48	0.54
C	X	$\frac{1}{2}$	0.84	1.40	1.60	1.94	0.24	0.32	0.38	0.47
C	Y	1	1.17	1.81	2.00	2.26	0.28	0.44	0.48	0.54
C	Y	$\frac{3}{4}$	1.15	1.67	1.90	2.22	0.26	0.38	0.43	0.47
C	Y	$\frac{1}{2}$	0.92	1.44	1.59	1.93	0.22	0.25	0.34	0.40
C	Z	1	1.05	1.60	1.85	2.25	0.29	0.44	0.54	0.56
C	Z	$\frac{3}{4}$	1.05	1.54	1.76	2.07	0.28	0.35	0.45	0.46
C	Z	$\frac{1}{2}$	0.75	1.32	1.53	1.84	0.22	0.33	0.34	0.45

APPENDIX 1, TABLE II—DENSITY AND CONTRAST FOR $\frac{5}{8}$ INCH OF ALUMINUM

Film	Develop- ing Solu- tion	Concen- tration	Density				Contrast			
			3	5	6	8	3	5	6	8
			min	min	min	min	min	min	min	min
A	X	1	0.54	0.86	1.05	1.23	0.16	0.28	0.31	0.36
A	X	$\frac{3}{4}$	0.61	1.02	1.20	1.37	0.18	0.28	0.31	0.34
A	X	$\frac{1}{2}$	0.59	0.96	1.16	1.24	0.17	0.31	0.31	0.34
A	Y	1	0.71	1.06	1.21	1.35	0.22	0.31	0.35	0.37
A	Y	$\frac{1}{2}$	0.62	0.99	1.11	1.29	0.18	0.28	0.33	0.34
A	Z	1	0.68	1.08	1.13	1.34	0.19	0.30	0.32	0.39
A	Z	$\frac{1}{3}$	0.56	0.99	1.14	1.36	0.17	0.29	0.29	0.33
B	X	$\frac{3}{4}$	0.42	0.84		1.32	0.14	0.29		0.38
B	X	$\frac{1}{2}$	0.39	0.75	0.93	1.26	0.14	0.25	0.28	0.33
B	Y	1	0.62	1.08	1.25	1.55	0.19	0.30	0.31	0.37
B	Y	$\frac{3}{4}$	0.59	1.04	1.21	1.50	0.19	0.28	0.31	0.37
B	Y	$\frac{1}{2}$	0.50	0.90	1.09	1.40	0.14	0.25	0.27	0.34
B	Z	1	0.60	0.93	1.08	1.37	0.22	0.30	0.30	0.36
B	Z	$\frac{3}{4}$	0.50	0.90	1.05	1.37	0.16	0.27	0.31	0.35
B	Z	$\frac{1}{2}$	0.44	0.83	0.95	1.21	0.13	0.23	0.30	0.31
C	X	1	0.44	0.77	0.88	1.12	0.14	0.28	0.31	0.37
C	X	$\frac{3}{4}$	0.52	0.86	1.03	1.26	0.19	0.30	0.33	0.36
C	X	$\frac{1}{2}$	0.46	0.82	0.95	1.18	0.14	0.26	0.29	0.33
C	Y	1	0.68	1.07	1.20	1.32	0.22	0.31	0.32	0.34
C	Y	$\frac{3}{4}$	0.68	1.03	1.15	1.32	0.20	0.29	0.32	0.38
C	Y	$\frac{1}{2}$	0.54	0.93	1.02	1.24	0.16	0.25	0.25	0.30
C	Z	1	0.56	0.92	1.05	1.29	0.19	0.30	0.33	0.39
C	Z	$\frac{3}{4}$	0.58	0.90	1.06	1.26	0.20	0.30	0.30	0.34
C	Z	$\frac{1}{2}$	0.42	0.76	0.92	1.14	0.11	0.23	0.28	0.30

In Figure 1 there are shown four curves corresponding to the four developing times used for a given make of film, C, and a given make of developing solution, Z, at normal concentration. Since the corre-

investigation were obtained by considering three points on each curve. The three points chosen were those corresponding to thicknesses of aluminum of $\frac{3}{8}$ inch, $\frac{5}{8}$ inch, and $\frac{7}{8}$ inch, respectively. These

thicknesses produce densities, for normal developing solution concentration and average time of development of from five to curves show that there is no reason for using a developing time less than five minutes since this would result in much

APPENDIX I, TABLE III —DENSITY AND CONTRAST FOR $\frac{7}{8}$ INCH OF ALUMINUM

Film	Develop- ing Solu- tion	Concen- tration	Density				Contrast			
			3 min	5 min	6 min	8 min	3 min	5 min	6 min	8 min
A	X	1	0.29	0.42	0.54	0.62	0.09	0.13	0.20	0.25
A	X	$\frac{3}{4}$	0.33	0.53	0.65	0.80	0.11	0.21	0.23	0.25
A	X	$\frac{1}{2}$	0.31	0.46	0.61	0.64	0.10	0.18	0.23	0.25
A	Y	1	0.36	0.54	0.64	0.74	0.14	0.21	0.22	0.25
A	Y	$\frac{3}{4}$	0.33	0.50	0.56	0.71	0.11	0.20	0.22	0.25
A	Z	1	0.36	0.59	0.59	0.69	0.13	0.19	0.20	0.26
A	Z	$\frac{1}{2}$	0.30	0.51	0.61	0.78	0.10	0.18	0.23	0.25
B	X	$\frac{3}{4}$	0.22	0.40		0.67	0.07	0.16		0.28
B	X	$\frac{1}{2}$	0.20	0.36	0.44	0.68	0.06	0.14	0.16	0.26
B	Y	1	0.33	0.54	0.72	0.92	0.11	0.22	0.22	0.30
B	Y	$\frac{3}{4}$	0.33	0.56	0.65	0.89	0.10	0.19	0.22	0.26
B	Y	$\frac{1}{2}$	0.28	0.46	0.58	0.83	0.08	0.15	0.22	0.26
B	Z	1	0.30	0.46	0.56	0.73	0.10	0.18	0.22	0.27
B	Z	$\frac{3}{4}$	0.25	0.46	0.52	0.74	0.09	0.16	0.22	0.28
B	Z	$\frac{1}{2}$	0.23	0.42	0.45	0.61	0.08	0.15	0.17	0.25
C	X	1	0.22	0.36	0.40	0.51	0.09	0.14	0.16	0.24
C	X	$\frac{3}{4}$	0.26	0.40	0.47	0.61	0.10	0.15	0.20	0.28
C	X	$\frac{1}{2}$	0.23	0.39	0.46	0.57	0.08	0.16	0.20	0.26
C	Y	1	0.34	0.54	0.64	0.74	0.12	0.21	0.22	0.24
C	Y	$\frac{3}{4}$	0.35	0.54	0.59	0.74	0.13	0.20	0.24	0.25
C	Y	$\frac{1}{2}$	0.29	0.50	0.55	0.70	0.10	0.17	0.21	0.24
C	Z	1	0.29	0.44	0.50	0.65	0.11	0.16	0.21	0.26
C	Z	$\frac{3}{4}$	0.28	0.44	0.54	0.68	0.11	0.16	0.23	0.25
C	Z	$\frac{1}{2}$	0.24	0.40	0.45	0.59	0.07	0.16	0.18	0.22

six minutes, which fall approximately at the two extremes and the middle of the useful density range of 0.4 to 1.5. This method of abstracting the required data eliminates the necessity for reproducing all the curves and permits the presentation of the data in tabular form. These data are presented in the four tables in Appendix I. In tables I, II, and III the values of density and contrast for $\frac{3}{8}$ inch, $\frac{5}{8}$ inch, and $\frac{7}{8}$ inch of aluminum are recorded. Table IV contains the fog values obtained in the shadows of the lead strip.

From Tables I, II, III, and IV there are drawn curves of density against time of development and contrast against time of development for each of the three aluminum thicknesses, and also fog against time of development. In Figures 2, 3 and 4 there are shown curves of density, contrast, and fog, respectively, against time of development plotted from the data corresponding to the curves of Figure 1 for film C, developing solution Z, and normal developing solution concentration. These

APPENDIX I, TABLE IV —FOG

Film	Develop- ing Solu- tion	Concen- tra- tion	3	5	6	8
			min	min	min	min
A	X	1	0.11	0.14	0.15	0.18
A	X	$\frac{3}{4}$	0.11	0.17	0.18	0.21
A	X	$\frac{1}{2}$	0.13	0.15	0.16	0.17
A	Y	1	0.13	0.16	0.18	0.21
A	Y	$\frac{1}{2}$	0.12	0.13	0.15	0.18
A	Z	1	0.14	0.16	0.15	0.19
A	Z	$\frac{1}{2}$	0.12	0.15	0.17	0.21
B	X	$\frac{3}{4}$	0.10	0.14		0.17
B	X	$\frac{1}{2}$	0.11	0.11	0.13	0.17
B	Y	1	0.11	0.16	0.20	0.26
B	Y	$\frac{3}{4}$	0.12	0.18	0.20	0.30
B	Y	$\frac{1}{2}$	0.12	0.15	0.16	0.22
B	Z	1	0.12	0.14	0.16	0.22
B	Z	$\frac{3}{4}$	0.11	0.16	0.15	0.20
B	Z	$\frac{1}{2}$	0.11	0.13	0.14	0.16
C	X	1	0.07	0.08	0.09	0.09
C	X	$\frac{3}{4}$	0.07	0.09	0.09	0.10
C	X	$\frac{1}{2}$	0.07	0.08	0.09	0.09
C	Y	1	0.07	0.09	0.14	0.18
C	Y	$\frac{3}{4}$	0.08	0.10	0.11	0.17
C	Y	$\frac{1}{2}$	0.07	0.09	0.10	0.15
C	Z	1	0.08	0.09	0.09	0.12
C	Z	$\frac{3}{4}$	0.08	0.09	0.10	0.14
C	Z	$\frac{1}{2}$	0.09	0.08	0.09	0.10

lower density and contrast with very little diminution of fog. A developing time greater than six minutes produces a less rapid increase in density except for the very

low densities under $\frac{7}{8}$ inch of aluminum and a much less rapid increase in contrast, especially for the $\frac{3}{8}$ inch and $\frac{7}{8}$ inch alu-

In order to investigate the variation of density and contrast with variation of developing solution concentration the data

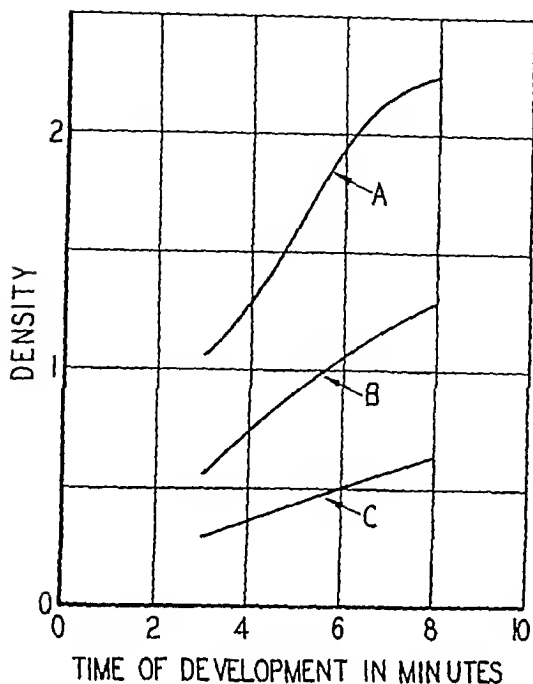


Fig 2 Variation of density with time of development Film C, developing solution Z, normal concentration thickness of aluminum A, $\frac{3}{8}$ inch B, $\frac{5}{8}$ inch, C $\frac{7}{8}$ inch

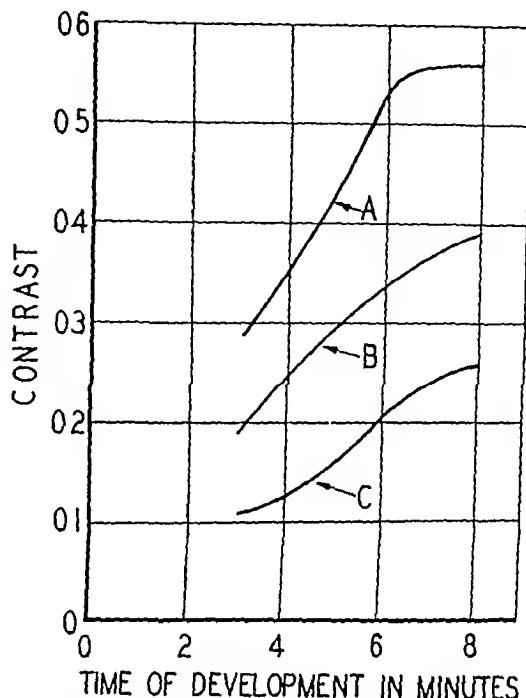


Fig 3 Variation of contrast with time of development Film C, developing solution Z, normal concentration thickness of aluminum A $\frac{3}{8}$ inch, B, $\frac{5}{8}$ inch C $\frac{7}{8}$ inch

minum thicknesses, while the fog is beginning to increase very rapidly. Since increased development time may also result in shorter developing solution life, it seems inadvisable to employ a development time greater than six minutes. The choice of developing time, therefore, lies in the interval between five and six minutes, and it would appear preferable to use six minutes in view of the increased density and contrast without appreciable increase of fog. While the life of the developing solution may be less if six-minute developing time is used, the load on the x-ray tube will be decreased with a consequent lengthening of its life. The data for film C and developing solution Z at normal concentration have been presented and interpreted. The data for the other films and developing solutions exhibit the same characteristics.

for $\frac{5}{8}$ -inch aluminum thickness and six-minute development time only were used, since the form of the variation was found to be independent of these two factors. Values of density and contrast for each make of developing solution and each value of de-

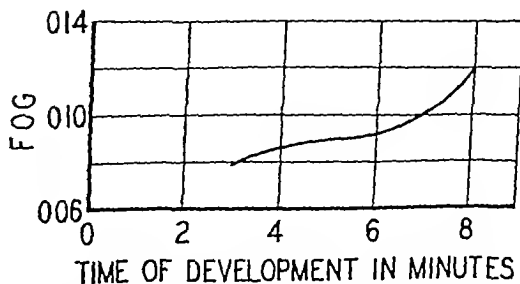


Fig 4 Variation of fog with time of development Film C, developing solution Z, normal concentration

veloping solution concentration were computed by averaging the values obtained under each condition for the three makes of film. For example, the value of density for normal concentration of developing solution Z was obtained from the data in the following manner. Film A developed in developing solution Z for six minutes at normal concentration resulted in a density of 1.13 under $\frac{5}{8}$ inch of aluminum. Film B under the same conditions produced a density of 1.08, while for film C the density was 1.05. The average of these three densities is 1.09, and this average value was taken as the value of density for normal concentration of developing solution Z for the specified time of development and aluminum thickness. Density and contrast values for the various concentrations of all developing solutions were computed in the same fashion. Curves drawn from these computed values are shown in Figures 5 and 6. The most striking feature of these curves is the smallness of the variations in density and contrast as the value of the developing solution concentration varies from normal to one-half normal. This shows that in general the developing solution concentration is not a very critical factor when the solutions are fresh. However, while the effect of concentration on the life of the developer cannot be determined from these tests, several experiences in roentgenographic laboratories would indicate that the life is considerably shortened by reduction in solution concentration.

It is also interesting to note that developing solution X produces greater densities and contrasts for a concentration of three-quarters normal than for normal concentration. Developing solutions Y and Z produce decreasing densities and contrasts for decreasing developing solution concentration. This might indicate the advisability of a change in the quantities of some or all of the chemicals used in the preparation of developing solution X.

From the above discussion it may be seen that the data required for relative speed and contrast comparison of the three makes of film and the three makes of developer

are the densities and contrasts produced by identical exposures for the three thicknesses

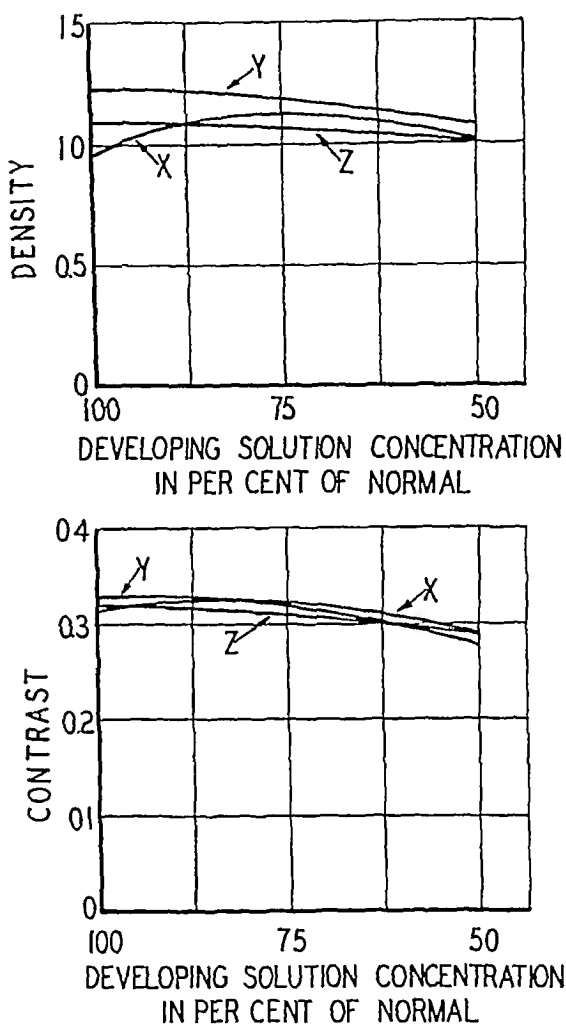


Fig 5 (above) Variation of density with developing solution concentration for the three developing solutions X, Y, Z, used in the first test, Section A. Each value of density for each developing solution is the average taken over the three films for six-minute time of development, $\frac{5}{8}$ inch of aluminum.

Fig 6 (below) Variation of contrast with developing solution concentration for the three developing solutions X, Y, Z, used in the first test, Section A. Each value of contrast for each developing solution is the average taken over the three films for six-minute time of development, $\frac{5}{8}$ inch of aluminum.

of aluminum, $\frac{3}{8}$ inch, $\frac{5}{8}$ inch, and $\frac{7}{8}$ inch. Since the variations of density and contrast with time of development are all similar in form it is necessary to use the data for only

one time of development, for which six minutes has been chosen. And in spite of the singular results obtained with developing solution X, it is judged most fair to employ the data for normal developing solution concentration in making comparisons

SECTION B

While the data obtained in Section A would suffice for a comparison of the speed and contrast characteristics of different makes of film and developer, further tests are necessary to determine the constancy of these characteristics. In view of the unusual characteristics of developing solution X with regard to variation of solution concentration, it was decided to incorporate in the tests for constancy a further study of the effect of varying developing solution concentration. The interval between the time of making the tests described in Section A and that for conducting the second set of tests was six months.

Test Procedure—For the purposes of this test it was necessary to obtain strips of samples from new batches of the three makes of film having exposures identical with those given the strips in the previous tests. In this case, however, it was necessary to provide only nine strips of each make of film, since the time of development was to be held constant at six minutes. The procedure used in Section A was repeated in every detail, using the same x-ray apparatus, the same measurement and oscillographic apparatus, and the same cassette and screens. In addition, using the same procedure, three exposed strips of the original sample of film C were included to enable the two sets of tests to be correlated.

Samples from the new batches of the three makes of developing solution were prepared in the same manner as before, and the values of developing solution concentration chosen were the same: normal, three-quarters normal, and one-half normal. Before developing the strips of the three makes of film, the three exposed strips of the original sample of film C were developed, one in each developing solution, at normal concentration, a developing time

of six minutes and a temperature of 65° F. Exposed strips of each of the three makes of film were then developed in each of the three developing solutions at each of the chosen values of developing solution concentration, with six-minute time of development and a temperature of 65° F. After processing and drying, all the steps of each of the developed strips were measured with the same comparative photoelectric densitometer which was previously employed.

Results—Curves of density against thickness of aluminum were plotted for all film strips. The fog values and the density and contrast values for the three thicknesses of aluminum are presented in Appendix 2, Table I. It is now possible to make two separate comparisons of the relative speed and contrast characteristics of the three makes of film and of the three brands of developing solution, one comparison from the data obtained in Section A and the other comparison from the data on the new samples. Having developed exposed strips of the original sample of film C in the more recent samples of each of the three makes of developing solution, it is possible to correlate the two sets of data in such a way as to determine the variation of the speed and contrast characteristics of each make of film and each make of developing solution. These data also permit investigation of the effect of varying developing solution concentration. Any variations in this effect which have occurred in the six months' interval are obtained by comparing these data with the data of Section A.

Since the films were all identically exposed the most convenient method for expressing the relative speeds of any two makes of film or any two makes of developing solution is to use the ratio of the densities obtained in the two cases. The relative contrasts may be expressed in the same fashion. In Table A there are shown relative values of speed and contrast among the three makes of film and among the three makes of developing solution for each of the three thicknesses of aluminum used. The comparisons in Table A are for the original

samples tested in Section A. These comparisons and all those to be presented below refer to six-minute development and

developing solution are the averages taken over the three brands of film. It may be noticed that one make of film and one make

APPENDIX 2, TABLE I—DENSITY, CONTRAST, AND FOG FOR SIX-MINUTE DEVELOPMENT TIME

Film	Develop- ing Solu- tion	Concen- tration	Density			Contrast			Fog
			$\frac{1}{8}$ in Al	$\frac{2}{8}$ in Al	$\frac{7}{8}$ in Al	$\frac{1}{8}$ in Al	$\frac{2}{8}$ in Al	$\frac{7}{8}$ in Al	
A	X	1	2.09	1.43	0.82	0.33	0.33	0.27	0.20
A	X	$\frac{2}{1}$	1.83	1.24	0.71	0.32	0.28	0.24	0.19
A	X	$\frac{1}{2}$	1.53	1.05	0.61	0.25	0.23	0.21	0.16
A	Y	1	1.96	1.23	0.68	0.41	0.32	0.24	0.19
A	Y	$\frac{2}{1}$	1.83	1.14	0.63	0.38	0.30	0.22	0.18
A	Y	$\frac{1}{2}$	1.52	0.98	0.55	0.30	0.25	0.19	0.16
A	Z	1	2.01	1.27	0.70	0.42	0.33	0.25	0.18
A	Z	$\frac{2}{1}$	1.89	1.18	0.66	0.40	0.30	0.22	0.18
A	Z	$\frac{1}{2}$	1.59	1.01	0.57	0.33	0.26	0.19	0.16
B	X	1	2.14	1.23	0.60	0.47	0.40	0.25	0.18
B	X	$\frac{2}{1}$	1.93	1.14	0.53	0.40	0.37	0.23	0.16
B	X	$\frac{1}{2}$	1.50	0.87	0.41	0.35	0.28	0.18	0.14
B	Y	1	1.98	1.05	0.52	0.57	0.35	0.20	0.19
B	Y	$\frac{2}{1}$	1.79	0.99	0.49	0.42	0.33	0.18	0.18
B	Y	$\frac{1}{2}$	1.47	0.84	0.44	0.35	0.26	0.15	0.16
B	Z	1	2.02	1.09	0.49	0.51	0.40	0.20	0.16
B	Z	$\frac{2}{1}$	1.86	0.98	0.44	0.47	0.36	0.19	0.16
B	Z	$\frac{1}{2}$	1.48	0.76	0.35	0.43	0.28	0.14	0.14
C	X	1	1.92	1.19	0.65	0.40	0.31	0.20	0.26
C	X	$\frac{2}{1}$	1.69	1.06	0.61	0.37	0.27	0.18	0.23
C	X	$\frac{1}{2}$	1.43	0.88	0.50	0.32	0.23	0.16	0.20
C	Y	1	1.69	1.03	0.62	0.40	0.26	0.15	0.34
C	Y	$\frac{2}{1}$	1.56	0.96	0.57	0.37	0.24	0.15	0.29
C	Y	$\frac{1}{2}$	1.38	0.87	0.52	0.30	0.22	0.14	0.24
C	Z	1	1.90	1.14	0.64	0.46	0.31	0.18	0.29
C	Z	$\frac{2}{1}$	1.64	0.97	0.55	0.41	0.27	0.16	0.23
C*	X	1	1.82	1.01	0.51	0.51	0.33	0.17	0.21
C*	Y	1	1.57	0.88	0.48	0.44	0.27	0.14	0.26
C*	Z	1	1.61	0.84	0.44	0.52	0.28	0.14	0.20

* Sample of film C from original batch

normal developing solution concentration, as previously discussed. The values employed to determine either speed or contrast for a particular make of film are the averages of the values obtained with this make of film developed in each of the three brands of developing solution. In the same way the values for a particular make of de-

veloping solution are always assigned a value unity for both speed and contrast. Since these comparisons are entirely relative among the different types of film and among the different types of developing solution, it is convenient to choose one product in each group as an arbitrary reference base. Film A and developing solution X have been arbitrarily chosen in the two cases. It can be clearly seen from these comparisons that throughout the useful exposure range film A and developing solution Y have both greater speed and greater contrast than their competitors. The criteria for choosing films and developing solutions for use in a roentgenographic laboratory have been discussed in the Introduction. With these criteria in mind the results obtained from the data of Section A indicate film A and developing solution Y to have been the optimum choice at that time.

TABLE A

Film and developing solution comparison at the beginning of the six month interval for normal developing solution concentration and six minute time of development. Film A and developing solution X are arbitrarily chosen as bases of reference for this relative comparison.

Film		$\frac{1}{8}$ in Al Con- Speed		$\frac{2}{8}$ in Al Con- Speed		$\frac{7}{8}$ in Al Con- Speed	
		trast	trast	trast	trast	trast	trast
A	X	1.00	1.00	1.00	1.00	1.00	1.00
B	X	0.92	0.78	0.98	0.93	0.96	0.98
C	X	0.94	0.97	0.90	0.97	0.87	0.95
Developing Solution	X	1.00	1.00	1.00	1.00	1.00	1.00
	Y	1.22	1.08	1.30	1.06	1.47	1.24
	Z	1.11	1.13	1.16	1.03	1.21	1.18

Two sets of data taken at the beginning and the end of the six months' interval, respectively, are used to determine the change in speed and contrast during this period for any combination of a particular make of film and a particular make of developing solution. In order to separate the film change and the developing solution change it is necessary to consider the data obtained by developing exposed strips of the original sample of film C in the new samples of the three makes of developing solution. Before comparing these data with the original data for film C it is necessary to make corrections for the changes in speed, contrast, and fog during six months' storage of this film. Correction was made for the increase in fog by deducting from each of the measured densities an amount determined by the increase in fog under the lead strip and the density from which the deduction was made. The presence of this latter factor is due to the variation of the effect of fog throughout the density range. The amount added by fog to low densities is greater than the amount added to higher densities. In accordance with well-known fog correction formulas,⁸ one-half of the fog increase under lead was deducted from the densities for $\frac{3}{8}$ inch of aluminum, three-quarters of the increase from those for $\frac{5}{8}$ inch of aluminum, and seven-eighths of the increase from those for $\frac{7}{8}$ inch of aluminum. On the basis of private communication with a laboratory engaged in photometric work, the speed and contrast were assumed to have decreased by 20 per cent during six months' storage and correction was made by adding to the densities accordingly. Comparing these corrected data with the original data for film C, the change in each make of developing solution is determined. The film change and the developing solution change can then be separated.

It should be noted that while the figure of 20 per cent used in this computation is in some degree arbitrary and not to be con-

sidered precisely correct, any error introduced by this assumption will affect only the separation of the changes due to film and developing solution. The change in any combination of any film with any developing solution is completely determined from the data without the need for any assumption. The experience gained through this investigation indicates that the better method of separating film and developing solution changes consists of saving a portion of the chemicals used in preparing the original sample of one of the makes of developing solution and preparing a small amount of developer from these chemicals at the time of the next test. If the chemicals are kept tightly sealed in a cool place and the developing solution made from them in the proper amount to provide normal concentration, it should be possible to determine accurately the changes which have occurred in each make of film under investigation.

The results of the above computations are recorded in Table B for each of the three thicknesses of aluminum and for six-minute development time and normal developing solution concentration. The figures appearing in this table for speed or contrast variation for any particular make of film or developing solution represent the *ratio of the speed or contrast at the end of the six-month interval to that at the beginning of this time*. Examination of this table reveals variations in speed and contrast which in some cases are as great as from 25 to 30 per cent. These variations are in some cases increases, and in others they are decreases, and in general they are not uniform over the range from $\frac{3}{8}$ inch of aluminum to $\frac{7}{8}$ inch of aluminum. Film A, for example, exhibits decreases in both speed and contrast at $\frac{3}{8}$ inch of aluminum, while both speed and contrast have increased for $\frac{7}{8}$ inch of aluminum. Film B, on the other hand, has had an increase in speed and a very appreciable increase in contrast at $\frac{3}{8}$ inch of aluminum, while for $\frac{7}{8}$ inch thickness the speed has decreased and the increase in contrast is small. These variations are noted in practically every

⁸ Jones L. A. Photometric Sensitometry Jour Soc of Motion Pic Engs 17 pp 718-720

make of film and developing solution during the six-month interval. Whether they represent a long-term trend or simply dif-

proper direction to be justified as an appreciable improvement in the manufacturer's product. The variations for the other makes of film and developing solution have no justification and can result only in waste and confusion.

The investigation of the effect of varying developing solution concentration gives further evidence of changes in the various makes of developing solution. In Figures 7 and 8 there are shown curves of density and contrast, respectively, against developing solution concentration for each of the three makes of developing solution. These curves were obtained from the data in Appendix 2 in the same manner as those of Figures 5 and 6 were obtained from the data in Appendix 1. Comparison of the two sets of curves shows that developing solutions Y and Z have changed, now being more affected by changes in developing solution concentration than they previously were, but it is developing solution X which has changed most. This developing solution no longer produces greater densities and contrasts when diluted and it is now affected more than either Y or Z by variation of concentration. This change in developing solution X is undoubtedly closely related to the change observed in Table B.

TABLE B

Variation of speed and contrast during six-month interval expressed as the ratio of speed or contrast at the end of the interval to the speed or contrast at the beginning of this interval for six-minute time of development and normal concentration of developing solution

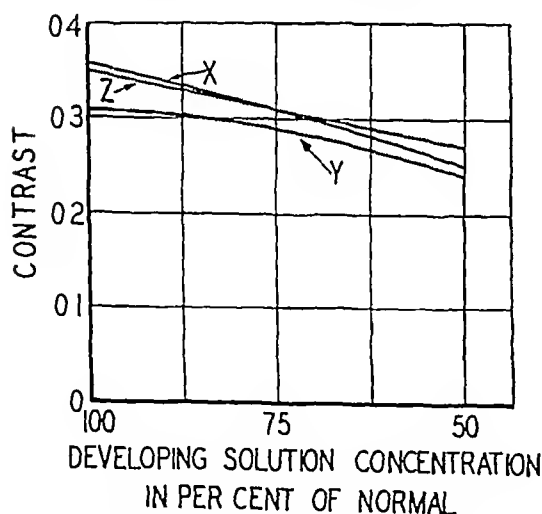
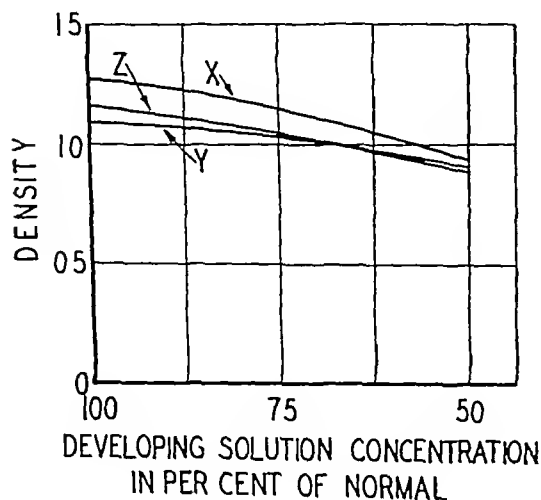
		$\frac{2}{3}$ in Al		$\frac{1}{3}$ in Al		$\frac{1}{3}$ in Al	
		Speed	Contrast	Speed	Contrast	Speed	Contrast
Film	A	0.94	0.75	1.15	0.91	1.27	1.15
	B	1.08	1.30	1.04	1.16	0.97	1.06
	C	0.92	0.85	1.06	0.85	1.25	0.90
Developing Solution	X	1.25	0.95	1.25	1.17	1.30	1.25
	Y	0.94	1.02	0.83	0.99	0.78	0.90
	Z	1.05	0.98	0.95	1.11	0.92	0.95

Fig 7 (above) Variation of density with developing solution concentration for the three developing solutions X, Y, Z, used in the second test. Section B. Each value of density for each developing solution is the average taken over the three films for six minute time of development $\frac{5}{8}$ inch of aluminum.

Fig 8 (below) Variation of contrast with developing solution concentration for the three developing solutions X, Y, Z, used in the second test. Section B. Each value of contrast for each developing solution is the average taken over the three films for six minute time of development $\frac{5}{8}$ inch of aluminum.

ferences between two emulsions, the effect on the reproducibility of roentgenographic results is identical. Only in the instances of Film B and developing solution X are the

After noting the changes which have occurred it is particularly interesting to make a comparison of the various types of film and developing solution at the end of the



comparison are recorded in Table C, the method for obtaining these results being identical with that used to obtain Table A.

TABLE C

Film and developing solution comparison at the end of the six month interval for normal developing solution concentration and six minute time of development. Film A and developing solution X are arbitrarily chosen as bases of reference for this relative comparison.

Film		$\frac{1}{8}$ in Al		$\frac{1}{4}$ in Al		$\frac{7}{8}$ in Al	
		Speed	Contrast	Speed	Contrast	Speed	Contrast
Film	A	1 00	1 00	1 00	1 00	1 00	1 00
	B	1 01	1 34	0 86	1 17	0 73	0 89
	C	0 91	1 08	0 86	0 90	0 87	0 70
Developing Solution	X	1 00	1 00	1 00	1 00	1 00	1 00
	Y	0 92	1 15	0 86	0 89	0 88	0 82
	Z	0 97	1 16	0 91	1 00	0 88	0 87

The procedure of choosing for use in the roentgenographic laboratory a make of film and a make of developing solution from Table C is now more difficult than was the choice from Table A. The non-uniformity of the variations observed in Table B is responsible for this difficulty. For exposures under $\frac{3}{8}$ inch of aluminum film B is obviously best, while for $\frac{7}{8}$ inch of aluminum film A is much superior to film B. At $\frac{1}{2}$ inch of aluminum the choice lies between a film having greater speed and one having greater contrast and since greater contrast will permit the use of a higher voltage and consequently more efficient technique film B is to be preferred. Thus it is seen that while film B is the better film over more than half the range its superiority is not too well defined. In the same manner developing solution X is to be preferred although developing solution Z has the advantage at $\frac{3}{8}$ inch of aluminum.

Recommended Processing and Test Methods—On the basis of the tests described in Section A it is concluded that the optimum processing conditions for fresh developer are

- 1 Normal developing solution concentration (preparation according to manufacturer's instructions),
 - 2 Developing solution temperature of 65° F,
 - 3 Development time of six minutes
- As the developing solution is used it is

important that the level in the tank be maintained and the time of development be increased to compensate for deterioration.⁹ The developing solution level is best maintained by the regular addition of small quantities of fresh developer to replace that which is carried away by the films or by evaporation. One pint of fresh developer should be added and stirred carefully after each group of ten 14 × 17 in films, or the equivalent, are processed. The calibration of the developing solution involves the use of strips of one make of film which have been prepared in a manner identical with that described in Section A. One of the strips is processed for 6 minutes at 65° F when the developer is fresh and used as a standard throughout the life of the developer. After about twenty-five films per five gallons of developer have been developed, three strips are processed for 6, 6.25, and 6.50 minutes. By measuring densities¹⁰ of the steps and plotting curves like those shown in Figure 1 these strips are compared with the standard, and the development time which produces densities equivalent to those of the standard strip is adopted for the next equal number of films. This procedure is repeated until it is impossible to obtain a processed strip equivalent to the standard, regardless of the time of development.

Consideration of the magnitude of the variations in films and developing solutions observed in Section B would indicate the

⁹ Charles Weyl and S. Reid Warren, Jr. *Apparatus and Technique for Roentgenography of the Chest*, page 136. Charles C. Thomas, 1935. W. E. Chamberlin and R. R. Newell, *Development of Roentgen Film: A Method of Determining the Potency of the Developer*, *Am Jour Roentgenol and Rad Ther*, May 1930, 23, 549.

¹⁰ If a densitometer is not available densities may be measured approximately by visual comparison with a standard strip of measured densities which may be obtained from one of the manufacturers of x-ray film. It is extremely important in making such a visual comparison that the standard step and the unknown step be placed side by side with edges touching and that the light from every portion of the viewing box other than that illuminating the two steps be blocked off. Covering the viewing box by a 14 × 17 in piece of cardboard with a rectangular hole just large enough for the two steps is a convenient method of providing the proper illumination.

advisability of testing these products at regular intervals. It is recommended that tests be performed every three months upon the films and developing solutions of the leading manufacturers. The results of the investigation described in Section A and Section B form the basis for the following recommended test procedure:

1. A can of prepared powders for making one gallon of developing solution should be obtained for each make of developer to be tested. One-half of the quantities in each can should be used to prepare one-half gallon of developing solution, according to the instructions of the particular manufacturer. The remaining half of the powders in one or more of the cans should be tightly sealed and kept in a cool place as a control for the next test three months later. The powders which have been held over from the preceding test in this manner should be used to prepare one-half gallon quantities of one or more makes of developer.

2. A roentgenographic exposure of the eight-step aluminum ladder described in Section A should be made on a piece of each make of film to be tested at the following technique:

X-ray tube voltage, 80 kv p ,

Average x-ray tube current, 100 ma ,

Time of exposure, $1/10$ second,

Focal spot-film distance, 72 inches

It is absolutely imperative that these exposures be carefully and precisely controlled, that no change in the apparatus shall have occurred since the preceding test, and that the same pair of intensifying screens be used.

3. Strips approximately one-half inch in width should be cut from the middle six inches of each piece of exposed film in the manner described in Section A. A strip of each make of film should be developed in each developing solution, including the one or more solutions made with powders preserved from the

preceding test. All strips should be developed for six minutes at a solution temperature of 65° F.

4. After the strips have been processed the densities should be measured and curves of density against thickness of aluminum like those shown in Figure 1 should be plotted for each strip. Density and contrast values should be obtained from these curves for $3/8$ inch, $5/8$ inch, and $7/8$ inch of aluminum for each film-developer combination.

Having obtained the necessary data concerning density and contrast, the analysis of these data may be made in a manner identical with that of Section B. The relative speeds of any two makes of film or developing solution may be expressed as the ratio of the densities obtained in the two cases, and the relative contrasts may be expressed in the same fashion. The values employed to determine either speed or contrast for a particular make of film should be the averages of the values obtained with this make of film developed in each of the brands of developing solution. In the same way the values for a particular make of developing solution are the averages taken over the various makes of film. The determination of changes in speed or contrast of any make of film may be made by comparing the data obtained from a strip of this film developed in a solution prepared with powders preserved from the preceding test and the data of the previous sample of this make of film which was developed in the solution prepared with the other half of the same powders during the preceding test. When the changes in speed and contrast for all makes of film under test have been determined the average speed or contrast change for all the films may be used in determining the speed or contrast change in any particular make of developer. Since the density or contrast values associated with a particular make of developer for the two tests are averages over all the films, the relationship between these two values is determined by the average film change and the developing solution change. When

the average film change is determined the change in the developer is easily computed. If more than one make of developer powders were preserved from the preceding test, this method of determining film and developer change may be repeated with the others to check the results obtained.

CONCLUSION

Modern technics for roentgen diagnosis require the highest possible degree of accuracy in the control of all mechanical, electrical, and photographic processes in order to obtain the maximum differentiation of shadows in the roentgenogram. Also, it is of extreme importance, particularly in connection with films of the chest, to have the highest possible standard of reproducibility. In the hands of the careful expert roentgenologist it has become possible to control the mechanical and electrical factors with reasonable precision. The application of careful experienced judgment will minimize the difficulties involved in the accurate calibration of the patient, and investigations being made of this problem give promise of the development of a precise scientific method of calibration. The photographic factor, unfortunately, is not so susceptible to accurate control by the roentgenologist.

Routine application of the recommended methods for the control of film processing

and for testing films and developers will enable the roentgenologist to use the films and developers available to the best advantage. Unfortunately the existence of the marked variations which have been observed in the characteristics of these products precludes the maintenance of a truly high standard of reproducibility. With respect to these variations the roentgenologist has no control and must rely upon the manufacturer for assistance.

It would be extremely helpful to the roentgenologist if the manufacturers of films and developers were to

- (a) Maintain as strictly constant as possible all batches of films and developers which are sold as identical,
- (b) Mark clearly, with a definite code number, any new or improved film or developer which differs in roentgenographic characteristics from its predecessors, or, include a sensitometric test strip in each package.

Roentgenologists are urged to make careful checks on films, developers, and processing methods in order to improve the constancy of their results.

The authors are convinced that the photographic materials and technics of roentgenography must be further standardized before any general improvement in optimum reproducible films can be introduced.

PHOTOGRAPHIC IMAGES OBTAINED IN TOTAL DARKNESS BY BOTH PENETRATION AND REFLECTION OF INFRA-RED RADIATION

By LEO C. MASSOPUST, *Milwaukee, Wisconsin*

Department of Anatomy, Marquette University School of Medicine

IN 1936 the author reported the results of observations on simultaneous infra-red roentgen photography (5). During the course of the experiments it was observed that (a) there was definite evidence that the activating ray had properties of penetration, (b) a photographic image was obtained in total darkness, (c) a photograph and a radiograph were obtained simultaneously on the same infra-red plate.

The present report concerns, principally, the use of the infra-red photographic plate under various conditions to confirm and in part to make an attempt at clarifying these phenomena.

It is also hoped that with some necessary improvements in the experimental equipment and technique this method may develop to such an extent that it will be of some definite use in the field of radiology.

In introducing the observations under consideration, it might be well to mention a few of the characteristics of radiant heat, the infra-red ray.

The radiation from a luminous object is of a composite character, a portion consists of what we term *light*, but a far greater part consists of infra-red rays, which do not excite the optic nerve. Thus, our senses do not tell us much about the special properties of the different wave length regions of the infra-red.

When light and heat from a luminous source fall upon a mirror, it is found that the heat follows the same direction as the reflected light. Hence, the laws of reflection of radiant heat are the same as those for the reflection of light. Heat is refracted according to the same laws as light. In consequence of refraction, heat is concentrated like light at the focus of a convex lens. If radiant heat falls upon an un-

polished surface it is scattered or diffused, reflection from it takes place at all angles and in all directions. The reflecting power of a substance is its property of throwing off a greater or less proportion of incident heat. Thus the relative reflecting power of polished brass is 100, while that of lamp-black is zero.

Beside thickness and color, the polish of a substance influences the transmission. Glass plates of the same size and thickness transmit more radiation as their surface is more polished. Bodies which transmit heat of any kind very readily, are not heated. Thus, a window pane is heated very little by the strongest heat from the sun.

Lamp-black absorbs the radiation from all sources in equal quantities, and very nearly completely. The behavior of polished metals is the reverse of that of lamp-black. They reflect the heat of different sources in the same degree. They are to heat what white bodies are to light.

A black body is one which completely absorbs all the radiation which falls upon it, being devoid of reflecting as of transmitting power. A lamp-black surface is practically a black body though not strictly so, for although it is perfectly black for visible radiations, it is not so for certain invisible radiations. When radiation falls on a black body the latter is heated, the energy of the incident radiation being transferred to the black body.

Materials, Methods, and Experimental Results—In all of the experiments the Eastman infra-ray plate, type 1R, is used. The light-tight box shown in the diagram, Figure 1, is constructed of wood and lined with lead. The so-called filter which closes over the window in this box is a photographic film holder slide marked with four dots, and is safe to use with the ordinary

emulsions but is unsafe to use as protection for the infra-red plate. Obviously the load-

red plate. The plate and card are placed in the light-tight lead-lined box (Fig 1), with

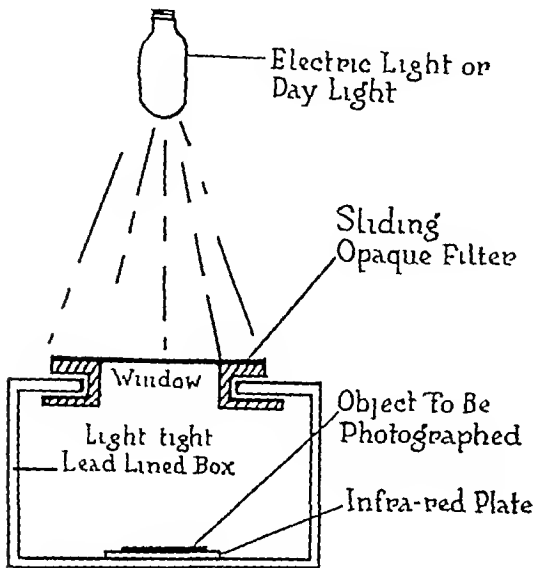


Fig 1 Light tight lead lined box

ing of the box and development of the plates has to be done in total darkness. Various methods and applications of infra-red materials are discussed in previous publications (1, 2, 3, 4, 5, and 6).

All of the photographs shown in this report are contact prints made from the original negatives.

In Figure 2, strips of red and blue cellophane are pasted over one side of a card having printed matter on both sides. The card is photographed with reflected light. Hence, a definite image of the cellophane and printed matter on one side of the card is obtained.

In Figure 3, the card is illuminated with transmitted light. A photographic film is placed over the card in the same manner as if a print were being made from a negative. The image of the strips of cellophane are also recorded on this plate, together with the printed matter on both sides of the card.

In Figure 4 the same card, containing the strips of colored cellophane, is placed in contact with the emulsion side of an infra-

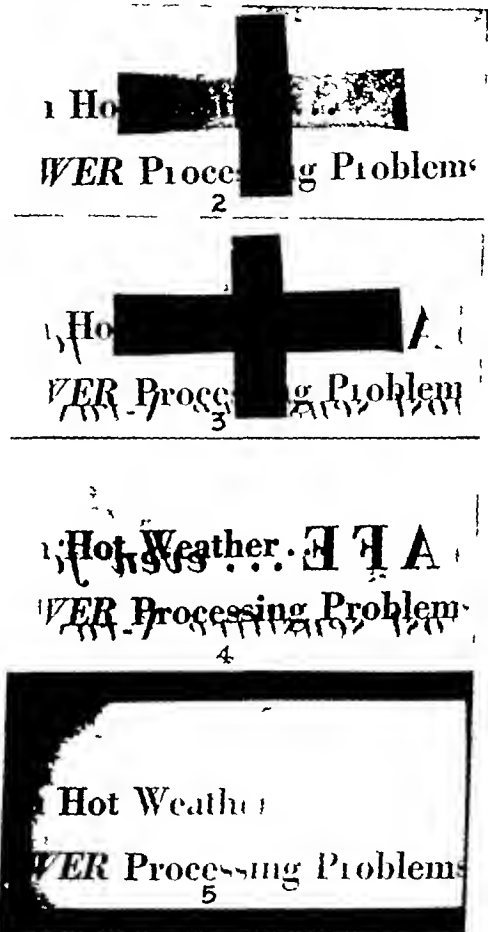


Fig 2 Photograph of a white card having printed matter on both sides and strips of red and blue cellophane pasted over the printed matter. Illumination was from a 500 watt tungsten bulb for 3 seconds with diaphragm set at F 22. Par speed portrait film. Contact print.

Fig 3 The same card as used in Figure 2 was illuminated with transmitted light and a sensitized film placed in contact with the card. Exposure time 2 seconds. Par speed portrait film. Contact print.

Fig 4 The same card as used in Figure 2 was placed on an infra red plate and the plate with the card placed inside the light tight lead lined box. The emulsion side of the plate was directed upward toward the window in the box. Illumination was from a 500 watt tungsten bulb for 5 seconds. Eastman infra red plate, type 1R. Contact print.

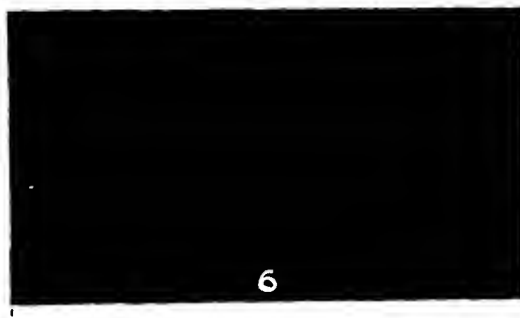
Fig 5 Same as Figure 4 except for the following changes. The card was placed on the bottom of the box while the infra red plate was turned over thus the emulsion side of the plate was in contact with the card and the back of the photographic plate was directed toward the window in the box. Exposure time 1 second. Contact print.

the emulsion side of the plate directed upward toward the window in the box. Illumination from a 500-watt tungsten bulb is directed over the opaque filter in the window of the box for five seconds. It is to be noted that the image of the cellophane is not recorded on the plate, that the background surrounding the card is white, and that the printed matter on both sides of the card is recorded on the plate. Hence, Figure 4 definitely establishes the conclusion that an invisible ray has penetrated through the card.

In Figure 5 the same card is placed on the bottom, inside the light-tight box. An infra-red plate is then placed on the card with the emulsion side in contact with the card and colored cellophane. Thus, the glass side of the plate is directed upward toward the window in the box. In other words, the activating ray must pass through the back of the sensitized plate and then through the emulsion before reaching the card. The illumination is the same as is used in Figure 4, but the exposure time is only one second. It is to be observed that only the printed matter on that side of the card in contact with the emulsion is recorded on the plate; that there is no image of the cellophane visible, and that the background surrounding the card is black. In view of this result it is safe to assume that Figure 5 has much the appearance of a reflected image. It is also interesting to note that in Figure 5 the radiation passes through the thickness of the glass plate and the emulsion before reaching the card, and that the exposure time is one-fifth that of Figure 4. In view of the fact that this invisible ray must pass through the plate and the emulsion before reaching the card, why does not the emulsion react uniformly? Or does the activating ray in this case become active only after striking the card and reflecting back to the emulsion?

Figure 6 is an ordinary photograph of a piece of heavy paper with printed matter on both sides. The illumination is reflected light from a 500-watt tungsten bulb. A heavy layer of lamp-black is deposited on the paper by smoke from a flame, con-

cealing all trace of the reading matter on the white card.



POLARIZING
MICROSCOPES

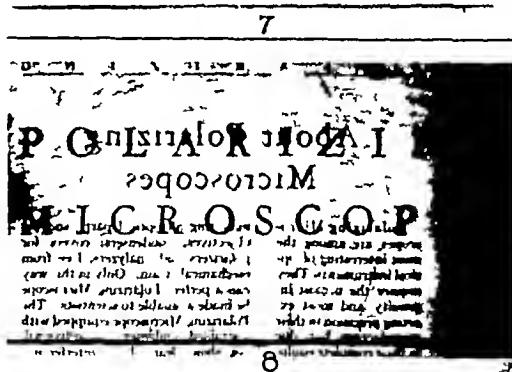


Fig 6 The printed matter on one side of a card was concealed by a deposit of lamp-black from a flame. Reflected light from a 500-watt tungsten bulb was used for 5 seconds. diaphragm set F 22. Par speed portrait film. Contact print.

Fig 7 Same as Figure 6 except for the following changes. The infra-red plate in conjunction with the Wratten No. 25 filter was used and the exposure time was 2 minutes. Contact print.

Fig 8 The same card was placed on the emulsion side of an infra red plate and the plate with the card placed inside the light tight lead-lined box. The emulsion side of the plate was directed upward toward the window in the box. Illumination was from a 500 watt tungsten bulb for 20 seconds. Eastman infra red plate, type IR. Contact print.

Figure 7 is photographed under the same conditions as Figure 6 with this difference—an infra-red plate in conjunction with the Wratten No. 25 filter is used. The printed matter, obscured by the lamp-black, is

clearly visible. It is stated above that the relative reflecting power of lamp-black compared to polished brass is zero, and is said to absorb invisible radiations. Yet in Figure 7 a comparatively clear photograph of the printed matter which was entirely concealed by the lamp-black, is obtained.

In Figure 8 the card is placed on an infra-red plate inside the light-tight box. Again the printed matter on both sides of the card is recorded on the plate. This result indicates that this invisible ray has penetrated the lamp-black and the card.

An attempt was made to duplicate the photographic results obtained in the light-tight box with an intense source of heat, but after a prolonged exposure from a glowing hot-plate, no activation of the emulsion was noted. These results were duplicated with daylight, however, at a temperature of five degrees below zero, Fahrenheit. Due to the fact that the daylight was less intense than the light from the tungsten bulb, a longer exposure time was necessary.

SUMMARY

In analyzing the experimental evidence thus far presented the following conclusions seem to be justified:

1. The infra-red plate responds very readily to wave lengths selected from visible light by an opaque filter.

2. An invisible ray has the properties of producing a photographic image by both penetration and reflection.

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6. Idem. Infra red Photography of Gross Anatomic Specimens. Arch Path 1937 23, 67-70.

SOURCES OF ERROR IN RADIOLOGICAL INTERPRETATION IN TUMORS OF BONE¹

By A C SINGLETON, M D, *Toronto, Canada*

From the Departments of Radiology, University of Toronto and Toronto General Hospital

THE diagnosis of tumors of bone remains one of the most difficult problems confronting surgeons, radiologists, and pathologists, and thus in spite of intensive study of the subject by large numbers of clinicians and research workers. The literature on every aspect of this problem is extensive, and great advances have been made in the diagnosis of these lesions. From the Bone Registry of the American College of Surgeons has come a workable classification of tumors of bone which has done much to bring order out of the chaos of confusing and clinically impractical terminology previously existing (Table I)

TABLE I—CLASSIFICATION OF BONE
REGISTRY

- 1 Metastatic tumors
- 2 Periosteal fibrosarcoma
- 3 Osteogenic tumors (benign and malignant)
- 4 Inflammatory conditions
- 5 Benign giant-cell tumor
- 6 Angioma (benign and malignant)
- 7 Ewing's tumor
- 8 Myeloma

Kolodny (1), in his masterly review of the material of the Bone Registry up to 1927, evolved a classification of primary malignant newgrowths of bone which is clear, concise, and very practical. His classification is as follows

- (A) Osteogenic sarcoma
- (B) Ewing's sarcoma
- (C) Myeloma
- (D) Unclassified sarcoma

The groups are arranged in the order of frequency of the various types of primary bone neoplasms. Osteogenic sarcoma is by far the most common of malignant bone tumors, accounting for about 80 per cent of all cases. Ewing's sarcoma has been

variously quoted as comprising from 7 to 15 per cent of cases, while myeloma is responsible for about 3 per cent of hemangio-endotheliomas and angiosarcomas of bone, which Kolodny carries in the unclassified group, and rare tumors as is also the periosteal fibrosarcoma.

There is no better illustration in the field of medicine of the need of close correlation of clinical and laboratory data than in the diagnosis of bone tumors. It is very hazardous to express an opinion on roentgenographs of bone lesions without having at least an accurate abstract of the clinical history, and any discrepancy between the two calls for a careful review of all the findings.

With regard to the roentgenographs themselves, no effort should be spared to obtain as good visualization of the tumor as possible. Films should be made in at least two directions if the lesion is in a long bone, and stereoscopic views if the lesion involves the trunk or skull. In these cases patients should be closely questioned as to the presence of symptoms in other parts of the body, and roentgenographs made of any area of which they complain. In certain cases it will be necessary to make films of the entire skeleton to show multiple primary lesions or the presence of metastases. In all cases of suspected primary malignant newgrowth of bone, chest films should be made to discover possible metastases, because of the fact that the chest is the commonest site of secondary involvement in malignant bone tumors.

The essential point in the radiological investigation of cases of suspected bone tumor is to determine whether the patient has or has not primary malignant disease of bone. This may well be approached by the following stages. First Has the pa-

¹ Read at the Fourth Annual Convention of the American Academy of Orthopaedic Surgeons, St. Louis Mo., Jan. 13, 1936.

clearly visible. It is stated above that the relative reflecting power of lamp-black compared to polished brass is zero, and is said to absorb invisible radiations. Yet in Figure 7 a comparatively clear photograph of the printed matter which was entirely concealed by the lamp-black, is obtained.

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- 4 Idem. The Use of the Infra red Plate in Photomicrography. Jour Biol Phot Assn., September 1936 5, 20-24.
- 5 Idem. Simultaneous Infra red Roentgen Photography. RADIOLOGY 1936 27, 663-666.
- 6 Idem. Infra red Photography of Gross Anatomic Specimens. Arch Path 1937 23, 67-70.

joints, where it is not possible to obtain roentgenographs showing all portions of the periphery of the involved bone (Fig 2)

ings As pointed out by Codman (2), they are either inside or outside the bone, but not both In enchondroma and benign



Fig 2-A

Fig 2-A Roentgenograph of shoulder shows mottled bone absorption in the neck of the scapula and in the head and neck of the left humerus associated with decrease in joint spacing in the shoulder joint These findings led to the opinion that this was an infective arthritis probably tuberculous

Fig 2-B

Fig 2-B Roentgenograph made of the same shoulder two months later shows an obvious tumor of the scapula Microscopically this was osteogenic sarcoma

In our own group of primary malignant bone tumors, this confusion of inflammatory lesions with newgrowth was responsible for about 50 per cent of the erroneous radiological diagnoses

The differential diagnosis of benign and malignant bone tumors is occasionally most difficult and sometimes impossible Indeed, the pathologist with multiple microscopic sections of the tumor is occasionally unable to state whether or not the tumor is malignant, or if the slides be submitted to a number of pathologists, there will be disagreement on the fundamental question of the presence and degree of malignancy Roentgenographs of typical benign bone tumors present fairly characteristic find-

giant-cell tumor there is usually intact cortex over the tumor except at the site of pathologic fracture, and there is a sharp clean-cut line of demarcation between tumor and normal bone In exostosis also the cortex is intact and continuous with cortex of the shaft of the bone and the tumor contains normal medulla A destructive solution of continuity of cortex, on the other hand, is in favor of malignant tumor An indefinitely outlined soft tissue mass associated with an osseous lesion is also in favor of malignant newgrowth of bone (Fig 3)

The differential diagnosis of primary and secondary malignant disease of bone may be divided into the consideration of single

tient a tumor of bone? Second Is the tumor benign or malignant? If malignant, is it primary or secondary?

tion parallel to the shaft Sequestration of moderately large areas of bone is not infrequent, and there is an evenness of den-

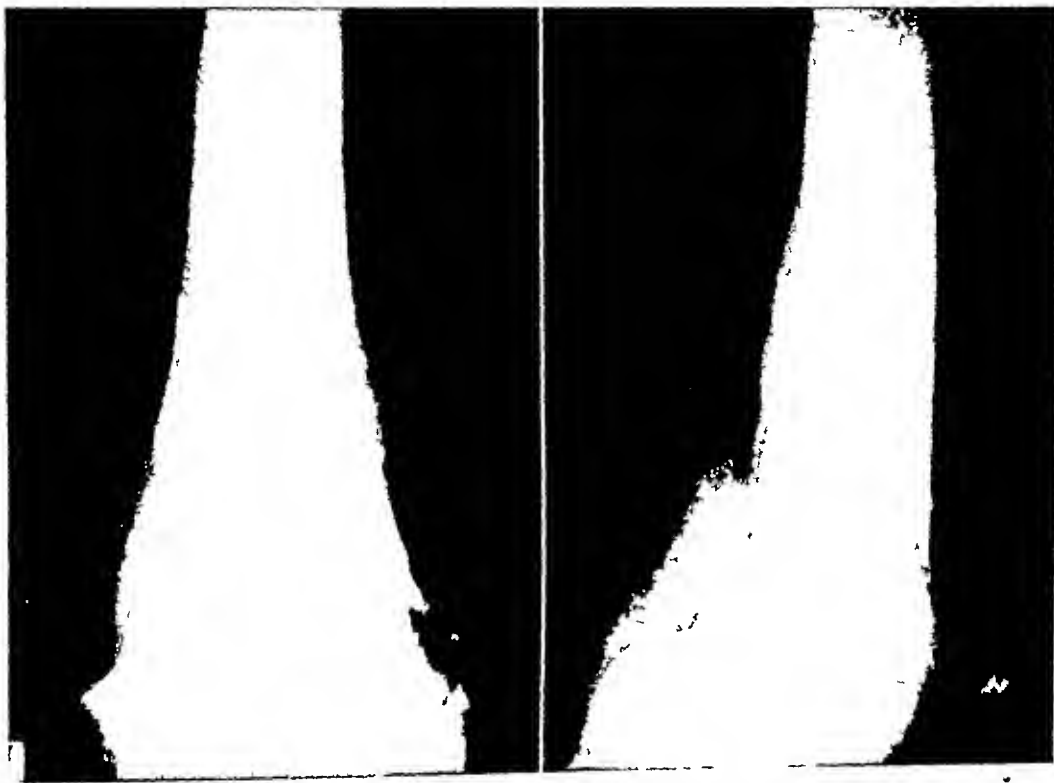


Fig 1 Illustrates the difficulty not infrequently experienced in differentiating between osteogenic sarcoma and osteomyelitis. The smooth subperiosteal new bone formation over the lower end of the femur led in this case to the erroneous diagnosis of osteomyelitis. Microscopically this was osteogenic sarcoma.

The differential diagnosis involved in the answer to the first question is between inflammatory disease of bones and joints, and newgrowth. The radiological differentiation of these lesions is frequently most difficult, and this first step in the radiological investigation of malignant bone tumors is productive of a large proportion of the errors of their diagnosis. The varying degree of response of bone to various types of infections, and at varying stages of disease, produces the widest variation in the roentgenographic picture in osteomyelitis. The changes are limited to the bone itself, and there is no soft tissue extension. There is elevation of periosteum early in the disease with sub-periosteal bone forma-

sity throughout the area of involvement in chronic cases. Osteomyelitis enters the differential diagnosis of bone tumors in two ways—first, the differentiation of chronic osteomyelitis from the osteoblastic type of osteogenic sarcoma (Fig 1), and second, the differentiation of early osteomyelitis from Ewing's sarcoma. In the latter case the similarity of the early clinical history in the two lesions may contribute toward confusion of diagnosis. In infective arthritis, the atrophy of bone close to the joint involved may simulate the irregular bone destruction of malignant tumor, and in the early stages of disease the differentiation of the two is not infrequently difficult, particularly in the spine, pelvis, and shoulder.

number of errors in radiological interpretation. The thorough clinical and radiological search for a primary carcinoma in patients of cancer age with skeletal lesions has unquestionably contributed largely in this regard (Fig. 4).

By carefully following the above points, the fundamental question as to whether or not a given lesion is primary malignant newgrowth of bone, may be answered in the majority of cases. However, there will always be a certain percentage of actual errors in interpretation, and a number of cases in which diagnosis is uncertain.

Having arrived at the opinion that a given lesion is in all probability a primary malignant tumor of bone, one must try to place it in one of the four main groups of primary malignant bone neoplasms. The classical radiological findings of the more common primary malignant bone tumors have been discussed so frequently that they need be referred to only briefly at this time.

Osteogenic sarcoma, which has the widest age incidence of any of the malignant bone tumors, presents varying degrees of bone production and destruction, and may be divided into osteoblastic and osteolytic types, based on the preponderance of one or the other characteristic. The osteoblastic type, when well marked changes have developed, presents a roentgenographic appearance which is characteristic. The young patient, with involvement of the diaphyseal region of a long bone, showing a spindle-shaped elevation of the periosteum, periosteal spur formation, radiating spicules of new bone at right-angles to the shaft, an indefinitely outlined overlying soft tissue mass, limitation of the growth by epiphyseal line, and the presence of the shaft of the bone unexpanded and possibly fragmented showing through the tumor, presents a picture which, once seen, is never forgotten. In cases in which osteolytic changes predominate, the radiological findings are less characteristic. There is usually seen, however, a mottled appearance of less than normal bone density in the end of a long bone, the involvement not infrequently

extending into the head of the bone if the epiphyseal line has fused. There is little or no expansion of the cortex, and actual destruction of cortex is a common finding. Pathologic fracture is not infrequent in this type of tumor. Osteogenic sarcoma is usually a solitary bone lesion although occasionally multiple tumors of this type are found. In such cases the question comes up as to whether they are true multiple primaries, or one primary with bone metastases.

Ewing's sarcoma in long bones usually presents the following findings. There will be a long area of involvement of the shaft, presenting increase in density of the medulla, elevation of the periosteum and formation of new bone in layers, giving the so-called "onion-skin appearance." Later in the course of the disease there will be areas of bone destruction within the lesion. Reference has already been made to the differential diagnosis of Ewing's sarcoma from early osteomyelitis. In our own group of cases the confusion of Ewing's sarcoma with osteogenic sarcoma has been a relatively frequent source of error. With regard to the therapeutic test of radiation, the response of our cases of Ewing's sarcoma has not been spectacular, and the response of osteogenic sarcoma has been so variable that we have found this test to be of little practical value in differentiating the two lesions.

Myeloma presumes the prefix, multiple, as only isolated cases of solitary lesions of this type have been reported. The multiplicity of bone lesions, the mature age of the patient, the characteristic sites of involvement, namely, ribs, spine, pelvis, clavicles, sternum, and skull, with frequently pathologic fractures of ribs or spine, and the absence of lung involvement, constitute the characteristic findings in this disease.

Periosteal fibrosarcoma produces pressure deformity on bone from without—but seldom, if ever, invades bone and does not essentially differ from fascial fibrosarcoma.

Angio-endothelioma and angiosarcoma

and multiple lesions. In solitary malignant newgrowth, the differential diagnosis will be among solitary secondary carcinoma

namely, the axial skeleton, upper ends of femora, the humeri, and skull. Of these two lesions there is much greater tendency



Fig 3 Illustrates the difficulty in certain cases of differentiating benign from malignant bone tumor. The irregular bone destruction in the neck of the femur with solution of continuity of cortex and indefinite outline between tumor and normal bone, led to the radiological opinion of malignant tumor in this case. Surgically and microscopically it was benign giant cell tumor.



Fig 4 This case illustrates the rather infrequent difficulty of differentiating between primary and secondary malignant newgrowth in bone. It was felt that this case presented the appearance of osteogenic sarcoma of the osteolytic type. It later proved to be metastatic fibro sarcoma from primary soft tissue sarcoma of the thigh.

and (a) osteogenic sarcoma, (b) Ewing's sarcoma, (c) extension of overlying soft tissue tumor to bone, (d) unclassified sarcoma of Kolodny's classification, (e) solitary myeloma. The age of the patient, the site of the lesion, the presence or absence of lung metastases, and the search for a primary extra-osteal newgrowth, will usually exclude carcinomatous or sarcomatous metastases, and extension of overlying tumor to bone. In multiple bone lesions the conditions most commonly to be differentiated are multiple myeloma and secondary carcinoma. Here the age incidence is the same for both lesions. The bones commonly affected are the same,

for carcinoma to destroy cortex of bone in an irregular manner, whereas myeloma tends to be more central and expansile. There is noted in many cases of myeloma, a tendency of the lesions to be rounded and uniform in size, particularly in the ribs, while secondary carcinomas are more likely to show wide variations of size and shape. The absence of chest metastases in the presence of multiple destructive bone lesions in a patient over forty should always suggest myeloma, particularly if no primary carcinoma can be found. The differentiation of primary and secondary newgrowth of bone in our own series of cases has been responsible for the smallest

THE ROENTGENOLOGIC IMPORTANCE OF THE LEFT OBLIQUE POSITION IN CHOLECYSTOGRAPHY

By MAURICE FELDMAN, M D , Assistant Professor of Gastro-enterology, *Baltimore, Md*

From the Department of Gastro-enterology, University of Maryland

THE technical difficulty of obtaining satisfactory visualization of the gall bladder in all instances is the cause of much skepticism in clinicians' minds regarding the reliability of cholecystography. Their criticism of the test is justly correct because they have experienced instances of normal operative findings in cases diagnosed by the roentgenologist as pathologic. The purpose of this presentation is to illustrate that it is not, as a rule, the cholecystographic test that is at fault, but rather the procedure in which the examination is performed. Since most roentgenographic examinations are carried out by technicians in busy laboratories, one must expect a certain small percentage of failures due to technical errors. However, the technician often lacks the experience in knowledge of the technical difficulties which underlie the principle of shadow visualization. It is to be regretted, too, that the roentgenologist often lacks control of the case, especially in hospital routine, and information regarding the patient's reaction to the dye, vomiting, diarrhea, and dosage is rarely given much attention. The routine carried out in the roentgenologic laboratory is of the greatest importance because in most instances it is here that the cholecystographic test is poorly managed. The non-visualizing gall bladder and that overshadowed by the bowel are the types which usually afford the greatest difficulty in diagnosis. There can be no question of doubt that true non-filling of the gall bladder represents a pathologic state in the biliary tract. However, it must be emphasized that in order to obtain the roentgenographic shadow of the gall bladder, sufficient technical knowledge is essential, since the proper roentgen

technic plays an important part in the portrayal of the cholecystogram. It has been shown, since the advent of cholecystography, that the gall bladder varies in position, and it also has been definitely established that it moves with respiratory excursions, the distance varying from one to three inches. Attention to the importance of obtaining views of the gall bladder in both inspiration and expiration must be pointed out, as it is often of considerable aid in the elimination of overlying shadows. Its importance is stressed (1) because its movement places the gall bladder in another position where it may be separated from overshadowing loops of colon, (2) by changing the position, gall-stone shadow within the gall bladder will normally move with the vesicle, thus determining whether or not it is within or outside of it, and (3) at times the gall bladder is situated close to the spinal column and respiratory movements not infrequently separate them.

Shifting of the x-ray tube will not infrequently separate the gall-bladder shadow from the colon, in most instances, however, this maneuver fails to accomplish the desired results. The routine roentgen technic for cholecystography has been fully described on numerous occasions. Although the similarity of technics differs little in the various roentgen laboratories, yet it must be pointed out that there are certain roentgenologic features regarding this test that are not fully appreciated. During the past few years, I have noted a large number of cases the films of which have been brought to me for diagnosis, revealing a non-visible gall bladder on which surgical interference has been advised for suspected biliary pathology. It was observed that the

are so rare and the radiological findings of the reported cases so atypical that no characteristic radiological findings have yet been evolved for these tumors. They are usually diagnosed as osteogenic sarcoma.

DISCUSSION

With regard to the fundamental question of whether a given lesion is or is not a primary malignant tumor of bone, a careful study of the radiological evidence will lead to a division of cases into—

- (A) Those lesions which are obviously malignant,
- (B) Those which are almost certainly benign,
- (C) Those in which there is doubt as to the benignity or malignancy of the lesion

Careful correlation of the clinical and radiological data in these cases will allow of a correct diagnosis in a large percentage of bone tumors. There will remain, however, an appreciable group of cases in which one cannot arrive at a definite diagnosis and in

which biopsy becomes imperative to obtain a basis for rational treatment.

The great question of the safety or advisability of doing biopsies in cases of bone tumors does not come within the province of the present discussion, but I do not believe that radiological investigation will obviate the necessity of microscopic examination of tissue, particularly in those cases in which radical surgical treatment is to be undertaken. Radiology has contributed very largely to the general knowledge of bone tumors and is of great value in their diagnosis. It must not be regarded, however, as supplanting other methods of investigation, but as an integral part of the scientific study of these cases. The careful correlation of clinical, radiological, and pathologic data is essential in arriving at the correct diagnosis as a basis for the evaluation of methods of treatment of tumors of bone.

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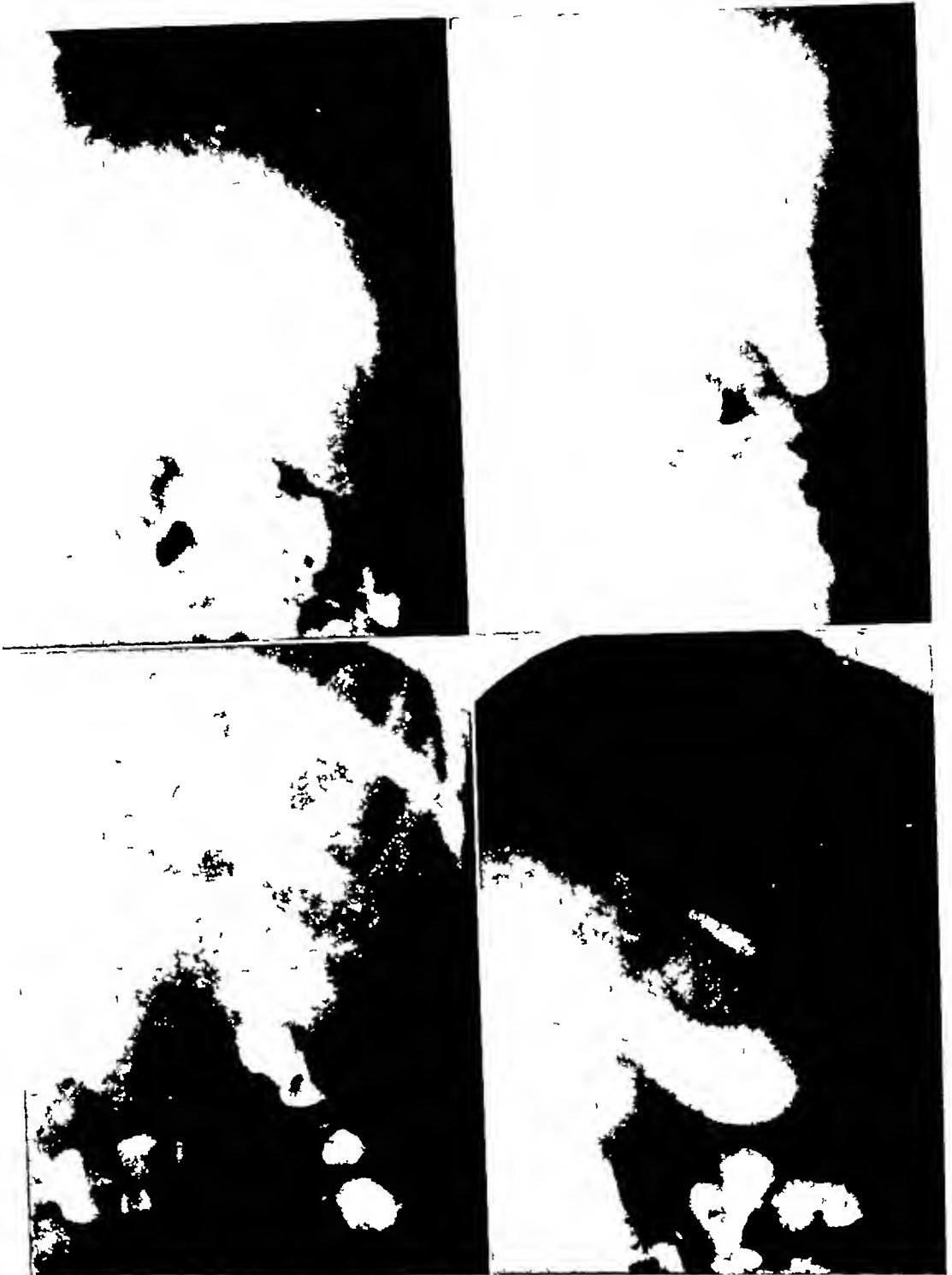


Fig 3-A (*upper left*) The lower half of the gall bladder is overshadowed by the hepatic flexure

Fig 3-B (*upper right*) Same case, made in the left oblique position reveals numerous small gallstones which could not be seen in the film made in the prone position because of the overlying colon

Fig 4-A (*lower left*) Roentgenogram made in the prone position showing the tip of the gall bladder overshadowed by the hepatic flexure.

Fig 4-B (*lower right*) Gall bladder made in the oblique position Note the greater increase in density of the shadow and its separation from the colon



Fig 1 A (upper left) Roentgenogram made in the prone position during the expiratory phase of respiration. Note the gall bladder overshadowed by the ribs.

Fig 1-B (upper right) Same case made during inspiration, in which the gall bladder is shifted to a lower level below the ribs.

Fig 2 A (lower left) Roentgenogram in prone position. A suspected double gall bladder is shown.

Fig 2-B (lower right) The left oblique position of same cases illustrates the tip of the gall bladder turned upward, producing the double shadow noted in Figure 2 A.

roentgenograms showing the non-visible posture and all were of similar technic. gall bladder were all made in the prone with unvarying position. It has been our

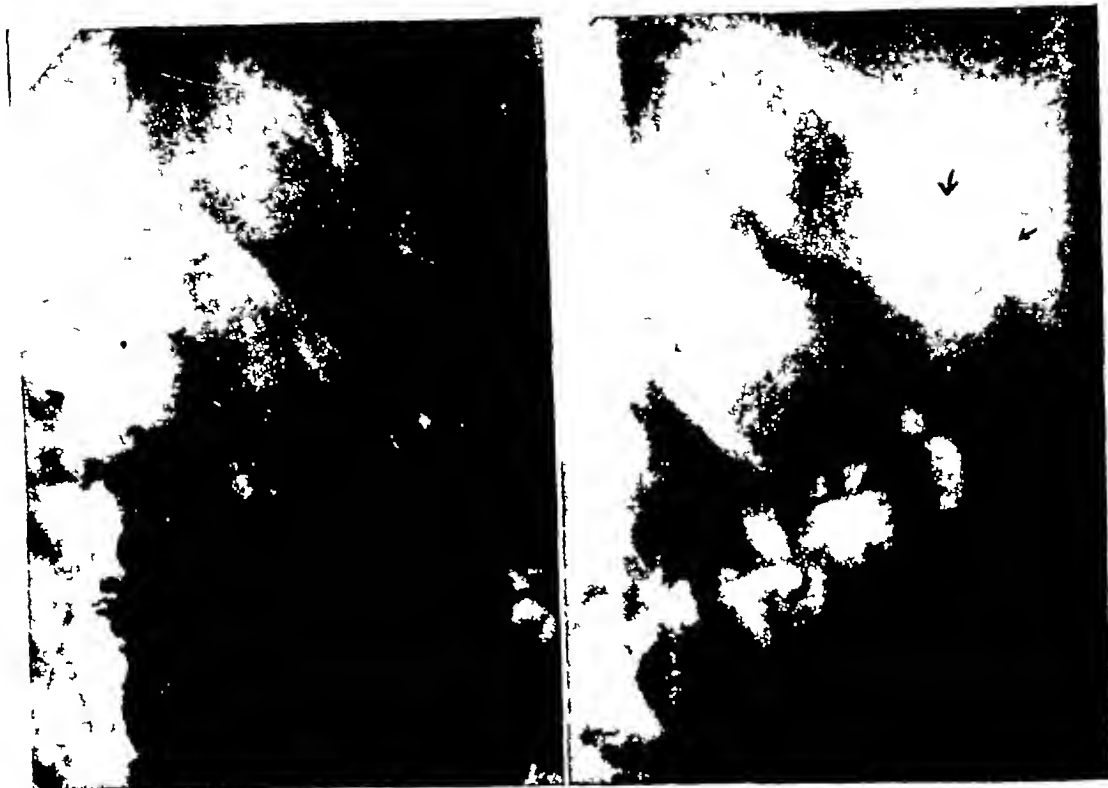


Fig 7-A (left) Gall-bladder shadow located close to the mid line (at arrow) Note the overshadowing of the spine This case was reported as one of non filling, being overlooked on account of its position
 Fig 7-B (right) Left oblique roentgenogram, illustrating the gall bladder shadow with a single medium-sized gallstone

it is essential to obtain views in the left oblique or left lateral positions with the left side next to the table. Interestingly enough, we have observed that this position gives an immense amount of information and is of inestimable value in demonstrating a gall-bladder shadow which in many instances could not be obtained by any other procedure. The left oblique or left lateral view is also of considerable aid in obtaining a better and more clear-cut picture of the gall-bladder shadow, separating it from the colon and thus enabling one to visualize the vesicle to greater advantage. At times, slight rotation of the abdomen to either the right or left side helps in eliminating extra-gall-bladder shadows. A gall bladder overshadowed by the spinal column will often be overlooked, but when the roentgenogram is made in the left oblique or left lateral

position the gall bladder is brought anteriorly and becomes clearly visible, enabling the roentgenologist to give an accurate report on the case instead of reporting a non-filling gall bladder. The greatest difficulty encountered by roentgenologists is overshadowing of the gall bladder by the hepatic flexure of the colon. The hepatic flexure not infrequently obliterates the vesicle shadow, which may at times be interpreted as a non-filling gall bladder. However, in most instances the gall bladder is only partly obscured by the colon. This type of case is also often misinterpreted, but by utilizing the left oblique or lateral view, errors of interpretation are minimized to a large extent.

SUMMARY

The greatest difficulty encountered by roentgenologists in the interpretation of

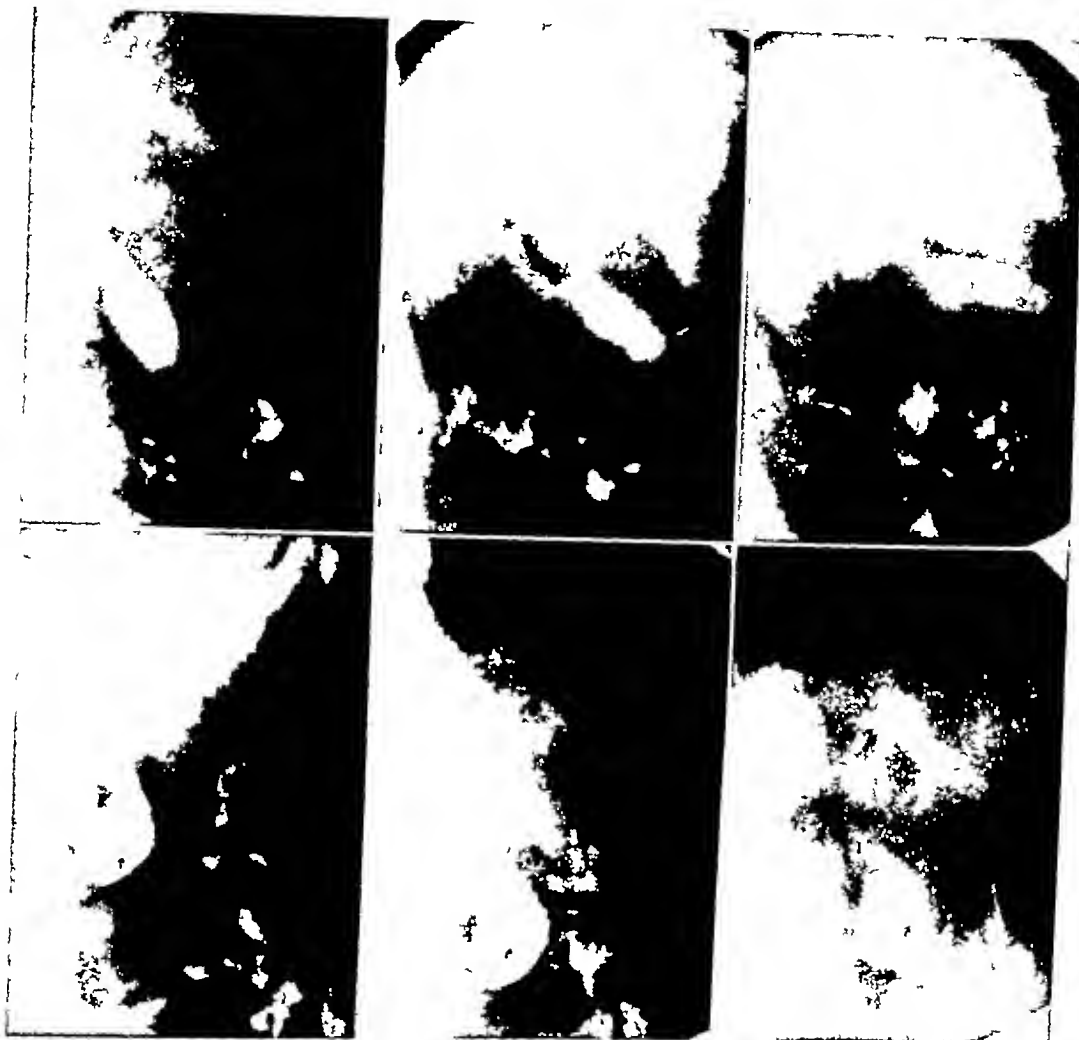


Fig 5-A (upper left) Gall bladder in prone position lying close to the spinal column. Note the extra shadow at its tip.

Fig 5-B (upper center) Oblique view showing a circular shadow at tip of gall bladder.

Fig 5-C (upper right) Lateral view illustrates a constriction at the tip of the gall bladder (at arrow).

Fig 6-A (lower left) Gall bladder in prone position situated close to the spine. Note the small single negative shadow (at arrow).

Fig 6-B (lower center) Same case with abdomen rotated slightly to the left showing the negative shadow still within the gall bladder.

Fig 6-C (lower right) Roentgenogram made in the left oblique position. Note the small negative stone shadow at arrow which has persistently shifted with the gall bladder. This case illustrates the importance of obtaining roentgenograms in different positions in order to eliminate overlying shadows.

custom not to rely upon such roentgenograms but to repeat the cholecystographic test. Upon careful investigation it was found that in many instances the gall bladder became visible by utilizing a special technic in this type of case.

In the routine roentgen examination of the gall bladder, films are made in the

prone position, in both inspiratory and expiratory phases of respiration. All cases in which there is non-visualization, overshadowing of the bowel, poor shadows, or cases which require shifting of the gall bladder to eliminate undetermined shadows require further investigation. Besides taking the above roentgenograms,

THE DEPENDENCE OF X-RAY ERYTHEMA ON WAVE LENGTH

By J CRAMER HUDSON, PH D , Collis P Huntington Memorial Hospital, *Boston, Mass*

THE roentgen as an x-ray dosage unit has been well established from a purely physical standpoint and is in general use throughout the world—at least for therapy work in which the radiation is generated at voltages up to two or three hundred kilovolts. It is generally, though not always, understood that this unit of dosage is based on purely physical principles, the physiologic effect produced by a roentgen of x-rays is not specified and must be determined experimentally.

Many radiologists feel that a knowledge of the erythema dose in roentgens is desirable and useful and the present paper presents a résumé of the results of such measurements taken on a number of therapy machines situated in the New England States. One object of these measurements was to determine whether or not the erythema dose as measured in roentgens depends upon wave length, a problem which has been investigated by numerous authors (1). In taking the various data recorded in this paper, the time of treatment for an erythema reaction on a particular machine was first secured from the roentgenologist in charge, and the total dose in roentgens determined from the product of treatment time in seconds and intensity in roentgens per second. In practically no case had the intensity from the machine been measured previously, the erythema time having been determined by trial only. All data as to machine settings, filter, treatment distance, and length of time of treatment were secured from the roentgenologist in charge and these same conditions were maintained for a particular series of measurements. In some instances the same machine was used under a number of different treatment conditions, and therefore a series of measurements was taken for each different setting of the machine.

In carrying out the measurements in a particular case, the roentgenologist in

charge or a technician operated the machine under as nearly identical conditions as those of treatment as possible and the intensity in roentgens per second was determined by means of a secondary ionization chamber. All measurements were made in air. The effective wave length was also determined in each case.

METHOD OF MEASUREMENT

In carrying out the various intensity measurements, four portable ionization dosimeters have been used at various times. Occasionally, measurements were taken on the same machine with two different instruments but this was not generally the case as the different dosimeters were always calibrated against a standard air chamber and so would naturally agree among themselves. The standard air chamber used for the calibration of the secondary chambers is of the type first used by Duane (2) and is set up permanently for calibration purposes in the Collis P Huntington Memorial Hospital, Boston.

Two of the dosimeters used in the measurements are Wulf Ionometers secured from Germany and recalibrated with the standard chamber. The calibrations received with the instruments for some reason did not agree with each other or with the standard chamber, but after being recalibrated they retained their calibrations quite satisfactorily, provided the rays entered the ionization chamber always from the same side. The chambers show a marked directional effect which may account in part at least for the poor agreement of their calibrations. They show also a small wave length effect and this must be taken into account, not only when making intensity measurements but also in determining the effective wave lengths.

The other two dosimeters are Victoreen instruments, one of them of the original type in which the ionization chamber is fixed permanently to the electrometer,



Fig 8-A (left) Case reported as non filling. Note shadow of the gall bladder close to the mid line overshadowed by the spinal column and psoas muscle.

Fig 8-B (right) Left oblique position of same case clearly demonstrates a well filled gall bladder shadow. Organ functioned normally revealing no evidence of stones but a constriction is noted at its tip.

cholecystograms is the type of case in which there is non-visualization or in which the gall bladder is overshadowed by the hepatic flexure.

Stress is laid upon faulty roentgen technique as a cause of diagnostic errors.

Emphasis is laid on the importance of obtaining views of the gall bladder in

different positions. The use of the left oblique or left lateral position affords the greatest aid in the portrayal of the gall bladder and in the elimination of extra-gall-bladder shadows. This procedure should be a routine measure in the cholecystographic study.

2425 Eutaw Place

number of milliamperere-minutes necessary to produce an erythema. It is obvious that milliamperere-minutes as an indication of dose is of little meaning in the case of unfiltered radiation.

same voltage and his value is, therefore, not strictly comparable to the value 325 r as found here.

In Figure 1 is plotted Curve A showing erythema dose in roentgens (measured in

TABLE II—FILTERED RADIATION

Machine	Spark Gap Voltage	Ma	Filter	Focus skin Distance	Intensity, r/sec	Time of Treatment	Total r	λ Eff Å
C	145	4	4 mm Al	30 cm	0.414	21.5 min	532	0.26
D	135	5	4 mm Al	20 cm	0.906	8 min	435	0.28
E	135	5	3 mm Al	25 cm	0.950	8 min	456	0.29
I	150	4	3 mm Al	30 cm	0.744	11.25 min	501	0.27
Average							480	28
A2	140	6	0.25 mm Cu	30 cm	0.440	20 min	530	0.22
C	145	4	6 mm Al	30 cm	0.343	27.5 min	570	0.23
I	150	4	0.25 mm Cu	30 cm	0.346	29 min	600	0.21
J	120	15	1 mm Al	50 cm	0.300	32 min	575	0.22
Average							570	22
I	165	4	0.5 mm Cu	30 cm	0.242	50 min	726	0.18
J	202	30	1 mm Al	50 cm	0.912	13 min	710	0.16
K	200	20	0.5 mm Cu	50 cm	0.667	17 min	680	0.17
L	200	20	0.5 mm Cu	50 cm	1.00	11.5 min	690	0.17
Average							700	0.17

The remainder of the observations have been placed in Table II and it is evident that all the data may be divided into three groups having effective wave lengths, measured by means of 0.25 mm Cu, of 0.27 Å, 0.22 Å, and 0.17 Å, and the erythema doses are 480, 570, and 700 roentgens, respectively. More variation is found, not only in the conditions operation but also in the number of roentgens necessary for an erythema. In all cases it is assumed that the radiation is all given at one sitting. This does not represent the usual practice in the case of 200 kv radiation, however, and for this radiation, in practically all instances, 800 or 900 r are given over a period of four or six days. It is interesting to note that Thoreaus (4) reports that in Sweden generally the erythema doses measured in air for approximately the same type of radiation are 450, 550, and 700 r as compared to 480, 570, and 700 r from the present data. He gives also 400 r as the erythema dose for 100 kv radiation filtered through 1 mm Al. This radiation is somewhat harder than unfiltered radiation at the

air) as a function of effective wave length. The points are the actual observations as taken from Table II, while the crosses represent the mean values of the dose for the

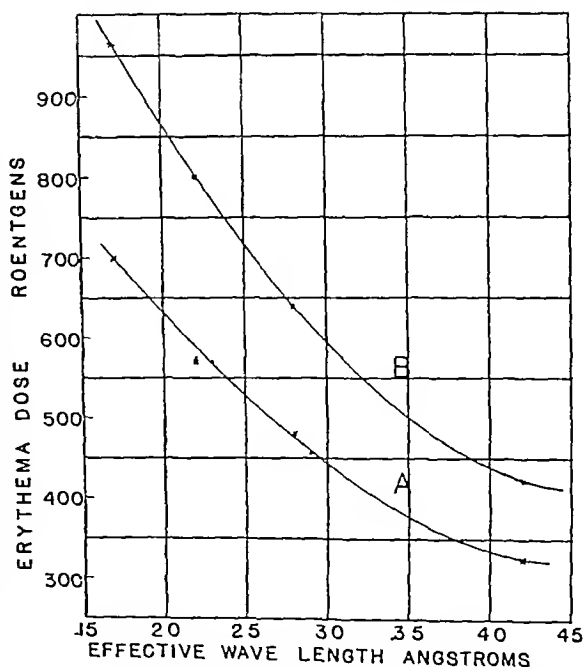


Fig 1 The erythema dose in roentgens for various effective wave lengths

the other is of the more recent condenser type. Neither of these showed any directional effect or any wave length effect over the region in which it was used, *i e*, from about 0.4 Å to 0.1 Å effective wave length. The first of these two instruments had to be adjusted slightly to bring its calibration into agreement with the standard chamber, but the second one, secured within the past year, has agreed consistently with the standard air chamber to within 1 per cent.

In specifying the quality of the radiation the effective wave length as defined by Duane (3) was measured. This consists in finding the percentage of radiation which passes through a quarter-millimeter of copper and from a curve showing percentage transmission as a function of wave lengths, the effective wave lengths may be read off. The great advantage of specifying quality in this fashion is the fact that one needs only a single added observation to make the determination.

In all cases a number of readings of intensity were made, and the average value is recorded in the data. The spark gap voltage, as recorded in the data, is the value secured from the machine in question either with a point gap or with a sphere gap with spheres 10 cm in diameter. Not too much reliance can be placed on these values, though they will give some indication of the approximate voltage on the roentgen-ray tube.

kv, and the radiation had an average effective wave length of about 0.4 Å. The letters in the extreme left-hand column designate the machine on which the measurements were made. The other data are self-explanatory. The first two data, A1 and A2, are of some interest since these represent two different tubes, operated on the same machine with presumably exactly the same operating conditions, as far as could be determined from switchboard settings, current, filter, etc. The tube used in A2 was a new tube with the glass quite clear, while that used in A1 was an old tube with a quite noticeable black deposit on the glass. One would suppose that this black film was probably tungsten and acted as an added filter to cut down the intensity of radiation, as there was a difference of 33 per cent in intensity. However, the added filter apparently caused no appreciable change in the effective wave length. The data in these cases indicate how much variation may be present, particularly when one uses unfiltered radiation, even though all settings as far as can be determined are the same.

The most interesting feature of Table I is the remarkable consistency in the number of roentgens necessary for any erythema. The mean value is 326 r, and no single value deviates from this by more than 6 per cent. It must be borne in mind too that most of these machines are not in the larger cities and so represent essentially

TABLE I—UNFILTERED RADIATION

Machine	Spark Gap Voltage	Ma	Filter	Focus skin Distance	Intensity r/sec	Time of Treatment	Total, r	λ Eff Å
A1	109	8	None	30 cm	3.34	100 sec	335	0.41
A2	109	8	None	30 cm	4.50	75 sec	338	0.42
B	120	5	None	30 cm	3.27	100 sec	327	0.43
C	100	4	None	30 cm	1.49	3.75 min	335	0.44
D	106	5	None	30 cm	4.92	70 sec	344	0.41
E	100	3	None	20 cm	2.33	2.25 min	315	0.42
F	100	4.5	None	30 cm	1.03	5 min	309	0.43
G	100	4.5	None	30 cm	2.12	2.5 min	318	0.42
H	100	4	None	30 cm	1.50	3.5 min	315	0.41
Average							326	0.42

The data are given in the accompanying tables, that for unfiltered radiation being in Table I. It is evident that most of these machines were being operated at about 100

independent experimentation to determine the erythema time.

One other feature is worthy of comment, and that is the wide divergence in the

X-RAY THERAPY IN AMENORRHEA

By ASA B FRIEDMAN, M D,¹ and BERNARD SELIGMAN, M D,² *New York City*

FUNCTIONAL disturbances of menstruation may often occur in women who have other evidences of glandular dyscrasias. Such secondary amenorrhea may or may not be associated with tumors of ovary, suprarenal or pituitary glands. When such tumors do exist there usually are more definite characteristic signs, such as defeminization or pituitary pressure symptoms. However, secondary amenorrhea often occurs without any definite evidence of tumor. It is further interesting to note that the symptoms of the climacteric are seldom present in functional amenorrhea.

The therapy of functional amenorrhea is, after the exclusion of local pathology such as tumor or pelvic inflammatory disease or other general debilitating conditions, either with ovarian and pituitary or thyroid substitution therapy, or by radiation therapy.

Mussey and Haines have reported 27 patients, between the ages of 16 and 29, with low basal metabolism rates and amenorrhea lasting from two to four years. The condition of 13 of these patients was benefited by glandular therapy. The longest duration of amenorrhea in any patient who responded to treatment was one year. The general health in 20 of these 27 patients was improved coincidentally with the elevation of the basal metabolic rate.

Treatment with female sex hormone has been reported by Zondak, Kaufman, Loesser, Dunn, and others. This form of therapy requires repeated intramuscular injections of large quantities of the hormones to establish and maintain the menstrual cycle. Menstruation has been induced and maintained with this form of hormonal substitution in many cases, in

one patient even after a nine-year amenorrhea. The treatment, however, requires enormous quantities of progynon B, is costly, painful, and time-consuming to the patient and physician.

Radiation therapy has been used in the treatment of functional amenorrhea with excellent results. Van de Velde, with the administration of small doses of the roentgen ray to the ovaries, successfully re-established the menstrual cycle. Werner and Ligner found that hypophyseal stimulation with the x-ray produced similar results. Since then Opitz, Frankel, Plateau, Thaler, Doderlein, Hirsch, Rubin, Rongy, Kaplan, Drips, Ford, and others have reported cases of amenorrhea and sterility in which good results have been obtained by x-ray therapy. Yet despite these favorable results, x-ray therapy for the treatment of functional amenorrhea has not received the recommendation it deserves.

Radiation therapy in functional amenorrhea is used on the premise that we are dealing with either an alteration in function of the pituitary gland or with ovarian dysfunction.

In 1915 Van de Velde, in discussing radiation in gynecology, reported the resumption of menstrual function following small doses of x-ray applied to the ovaries. In 1920, Monn reported eight cases similarly treated. In 1922, Thaler reported a series of 147. In 1926, I. C. Rubin reported 12, while in 1928 Kaplan reported 35 cases so treated—all by ovarian radiation alone. In 1931 Kaplan first mentioned the use of ovarian and pituitary radiation and in 1933 Edekin reported 56 cases with 40 successes. The majority had both ovarian and pituitary irradiation, but in one case only the pituitary region was treated. Most of these writers believe that radiation of the ovaries, with dosage too small to cause castration but large enough to be stimulative, offers no danger to the normality or health of the future offspring.

¹ Visiting Radiation Therapist, K. C. H., Div. of Cancer, Department of Hospitals, Ira I. Kaplan, M. D., Director.

² Associate Visiting Physician, K. C. H., Metabolic Clinic. H. Feinblatt, M. D.

mean effective wave lengths as determined from the three groups of the same table and also the mean value from Table I. These measurements were made in air without back-scatter. One may estimate the back-scatter for various wave lengths and sizes of field (4), and if this is done for a field of 10×10 cm, one secures the Curve B, Figure 1. It is evident that under actual conditions of treatment the number of roentgens necessary for an erythema dose depends on the wave length of the radiation

assumes the energy per roentgen incident on the skin is a constant over this wave length region, and also that there is no marked change in wave length of the scattered radiation. Both of these assumptions are approximately true for this limited region of wave lengths. These calculations indicate that, while the variation of erythema dose is more than twofold over this region, the *total energy* absorbed in the superficial layers of skin is practically constant. The *percentage* absorbed in surface layers is not the same for the various wave lengths, of course, and so one uses the shorter wave length radiation for deeper lying tumors.

SUMMARY

Experimental data are presented showing the variation of erythema dose in roentgens with effective wave length over the region from 200 kv, 0.5 mm copper filter, to 100 kv unfiltered radiation. Calculations indicate that the difference in dose necessary for an erythema at the various wave lengths is due chiefly to the difference in absorption by the tissue.

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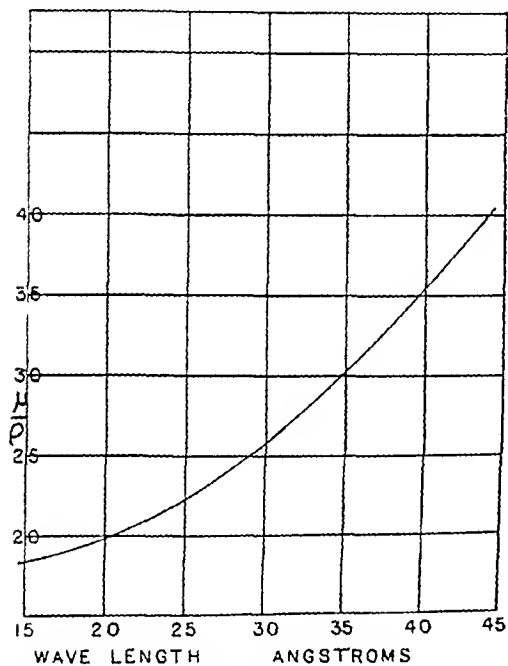


Fig 2 The mass absorption coefficient of water for various wave lengths

The absorption coefficient for tissue is practically that for water (5), the curve for which is shown in Figure 2, where mass absorption coefficient is plotted as ordinate and wave length as abscissa. Now one may calculate the amount of absorption by 1 mm thickness of tissue for each of the four mean effective wave lengths as given in the tables. Bearing in mind that the doses for a 10×10 cm field are 965 r, 800 r, 640 r, and 425 r for effective wave lengths 0.17 Å, 0.22 Å, 0.27 Å, and 0.42 Å, respectively, one finds that the amounts absorbed in the first millimeter of skin are 18, 17, 16, and 16 r for the corresponding wave lengths. Such a calculation

fore the birth of a baby three and one-half years previously, but since then had occurred every two to four months. She had noted an increased growth of hair on the upper lip, chin, and chest for the past two years. She complained of headaches at the top of the head. Her ankles are thin, her hands short and broad. She has thin eyebrows and considerable fine hair on the face. Pelvic examination was negative. X-ray examination of the sella turcica revealed a small calcific deposit superior to the anterior clinoid process. She received theelin 50 r units weekly for three months without effect. On Aug 27, 1934, her ovaries were irradiated and for two years since then she has menstruated regularly every 26 to 28 days, flowing normally two to three days. She has had two miscarriages during this period, both at five months.

Case 3 S R, aged 21 years, single, admitted to the clinic in 1933, complaining of obesity, hirsutism, and irregular menses. She began to menstruate at 13, menstruated regularly for two months, and then had intervals of amenorrhea of from 12 to 16 months between periods, at times the intervals were from four to five months. For the past six years she has had excessive hair on the face and body. She was treated with electrolysis but the hirsutism of the face recurred. She has always been overweight. Under clinic care and a reducing régime, she lost 30 pounds in one year. Theelin, antuitrin, and pituitary extracts had no effect on her menstruation. She has aberrant sexual impulses. Height 63 inches, weight 185 pounds. Blood pressure 106/80, basal metabolic rate plus 5 per cent. X-ray examination of the sella turcica is negative. Patient has shortening of the metacarpal bones as compared with the bones of the fingers. She is emotionally unstable and has had occasional palpitation. On Jan 15, 1934, x-ray treatments were started, 250 r to the pelvic and pituitary fields. She has been under observation for 30 months and has menstruated regularly. The diagnosis was functional basophilism.

Case 4 C R, aged 33 years, married, entered the clinic Jan 22, 1935, complaining of an amenorrhea for one year. She had scanty menses for eight years, every two or three months. She has had a marked gain of weight in the past year and moderate vertical headaches. She has two children, aged 9 and 4. Her weight is 174 pounds, height 64 inches, basal metabolic rate plus 7 per cent, blood pressure 119/76. X-ray examination of sella turcica negative. Moderate myopia, genitalia negative. Beginning April 10, 1935, x-ray therapy was administered to the pituitary and pelvic fields. Following treatment patient menstruated regularly every 23 to 28 days. The diagnosis was secondary hypogonadism.

Case 5 D R, aged 23 years, married, admitted April 14, 1934, complaining of irregular menstruation since the onset of her menses, three days every seven to nine months. She had typhus at eight years, had been married twice, the first time for three years and had a child of five. The second marriage has lasted four years. She has a slight yellowish leukorrhea and is constipated. She stopped growing at 18. She had a slight growth of hair on her face and chest and stated that her feet have grown larger in the past two years. She has gained 13 pounds in one year. Her weight is 153 pounds, height 61½ inches, blood pressure 110/80, basal metabolic rate plus 6 per cent, full face, large breasts, obese abdomen and hips, slight nuchal pad. X-ray examination of fingers shows partial gigantism, x-ray examination of the sella is negative. She menstruated last in August, 1933. She was given theelin 50 to 100 U R every week and small doses of thyroid for six months without result. On Oct 10, 1934, x-ray therapy to the pelvic and pituitary fields was started. Beginning Oct 25, 1934, she menstruated for four full days. The bleeding was more profuse than ever before and she menstruated regularly until she became pregnant, giving birth to a normal female child in December, 1935, her first pregnancy in seven

Small doses of x-ray irradiation did not produce any microscopically discernible degenerative changes in the ovaries of animals. Wagner and Schoenoff gave a patient 5 to 10 per cent SED to one ovary and carefully protected the other ovary. At operation, within two weeks following irradiation, specimens of both ovaries were obtained. The histologic picture in the irradiated ovary was exactly like that of the control ovary; no evidence of degenerative effects was found. Kaplan states definitely that small doses of x-ray, when properly administered, will not produce ill effects upon either the patient or the offspring. However, the question of the deleterious effect of x-ray dosage on the ovary (or testes), even when the dosage is too small to cause castration, is still a moot problem. Experimentally we know that the litter of irradiated mice or the succeeding generations of irradiated seedlings differ both in quantity and quality from those of controls even when the dosages used were very small. It is, therefore, not entirely logical to conclude that, because the immediate offspring of an x-ray-stimulated ovary is grossly normal, that the hereditary characteristics of the offspring have not been altered. Obviously it would require careful observation of many succeeding generations of the irradiated ovum to prove this point. Several generations of animals have been watched and alteration and hereditary characteristics have been demonstrated. It seems, therefore, in those cases in which pituitary radiation alone is adequate, we can avoid the problem of influencing heredity. It may be wrong to over-emphasize this point, because, as stated above, so many good workers deny any untoward influence.

The dosage we have used in the treatment of the pituitary region is approximately as follows: 200 to 250 r units at the sella turcica. The factors were 200 kv, 0.5 mm Cu plus 1.0 Al, 40 cm FSD, 200 r units to each of two lateral fields and one anterior field. The dosage used in the ovarian irradiation was kept below 100 r at the ovaries and administered through

three or four pelvic fields, usually two anterior and two posterior pelvic ports.

Regardless of the mode of action, evidence is fast accumulating that x-ray therapy to the pituitary gland and/or ovaries causes a return of the normal menstrual cycle. In some individuals the menses are re-established for a period of time and a second course of irradiation has to be given.

CASE REPORTS

Nine consecutive cases of favorable responses are presented for consideration.

Case 1 K. C., aged 28 years, housewife, admitted Jan 15, 1935, weight 210 pounds, height 64 inches, pulse 60, blood pressure 122/74, basal metabolic rate plus 6 per cent, urine negative, Wassermann negative. X-ray examination of the sella turcica showed calcification of the petroclinoid ligaments. Menstruation had always been irregular, occurring every two to three months and for one year she had had no periods. Menses were scant in amount, lasting two days. She had had two miscarriages, one in 1930 at six and one-half months and another in 1932 at four and one-half months. During the past five years she had gained 80 pounds and for three years had noted an increased growth of hair on the face, abdomen, and extremities. The diagnosis was a functional basophilism. She was given sex hormone therapy for eight months and menstruated Jan 17, 1935, and in March, 1935. On Sept 24, 1935, a course of x-ray therapy to the pituitary was given. She has menstruated regularly ever since and had a miscarriage at three months on Jan 8, 1936.

Case 2 A. G., aged 23 years, seen in the clinic May 22, 1934, weight 222 pounds, height 61 inches, blood pressure 132/90, basal metabolic rate, plus 7 per cent. Her mother is a diabetic. She complained of amenorrhea of one year's duration and of increased obesity of 23 pounds in 10 months. Her menses had begun at 13, with a 30- to 32-day interval, and a flow for three days. They had been regular be-

month later and continued regularly until a normal pregnancy a year thereafter. Diagnosis was hypo-ovarianism.

CONCLUSIONS

Nine consecutive cases of amenorrhea due to endocrinopathies were treated with small dosage of irradiation and in all regular menstruation was re-established. The treatment given is simple, harmless, and inexpensive. The endocrinologic stigmata other than the amenorrhea were not influenced by the treatment.

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years She was nursing the infant when last reported

Case 6 L R, aged 32 years, married, was admitted in 1934, complaining of amenorrhea for 17 years, frigidity and sterility She had a gradual gain in weight in 10 years from 150 to 262 pounds She complained of anorexia, crying, moaning, bad dreams, and frontal headaches She menstruated at 14 for three days She had poliomyelitis as a child, an appendectomy five years ago, pneumonia two years before, and influenza one year previously As a child she had nine operations on her legs for productive osteomyelitis She had a slight hypertrichosis of the breasts, chin, and extremities The mammae were small, there was a marked girdle obesity The posterior clinoid processes were anteriorly deviated Weight 262 pounds, height 5 feet 10 inches, blood pressure 152/100, basal metabolic rate plus 16 per cent The clitoris was twice the normal size, the cervix was small Blood calcium 9.5, phosphorus, 2.5, blood sugar 160 mgm per 100 c c In October, 1934, she was given a course of four treatments to the pelvic and pituitary fields Her menses were re-established for a period of 22 months She has not menstruated for the past two months and is now in the hospital under observation for abdominal pains

Case 7 E T, aged 18 years, single, entered the clinic in April, 1934, complaining of obesity, hypertrichosis, and amenorrhea of eight or nine months' duration She had begun to menstruate at 14 years She had always been fat, but as she grew older she grew stouter Since the age of 16 she had noticed growth of hair on her face and abdomen She had dyspnea, fatigue, and headache with eye strain Weight 236 pounds, blood pressure 164/114, basal metabolic rate minus 9 per cent, glucose tolerance, normal, girdle type of obesity, small breasts large clitoris She was always irregular in her menses, and went from three to ten months without a period In March, 1934, she received irradiation of the pelvic and pituitary fields She menstruated normally until Nov 16, 1935, and

has not been seen since Diagnosis is functional basophilism

Case 8 R W, aged 25 years, married, entered the clinic in November, 1935, complaining of irregular menses, loss of libido, and hair on face, chest, and arms for two and one-half years She had begun to menstruate at the age of 14, with periods of from five to six days, very irregular, increasing amenorrhea had lasted from two to six months She had been married for five years and was sterile About two years before she had begun to develop hair on the chin and chest which had grown progressively worse in the past few months She suffered severe frontal headaches, localized between the eyes She had gained 50 pounds in the past few years without any increase in food intake She tired easily and had palpitation on exertion She stood cold weather well She had been taking organic therapy without any result Was of a short, stocky type, alert mentally, large square head, thyroid slightly enlarged, smooth and symmetrical, normal visual fields, teeth well spaced, lineal stria on abdomen, skin thick and dry, blood pressure 88/60 On Nov 11, 1935, a course of four treatments to the pituitary fields were started In January, 1936, she had a second course of treatments because of her persistent amenorrhea, she has menstruated normally since

Case 9 G H, aged 21 years, admitted Aug 5, 1930, complaining of amenorrhea, sterility, and gain in weight Her menses had begun at the age of sixteen and one-half years, occurred only twice a year, but flowed moderately for eight or nine days when they did occur Dilatation and curettage were done a year previously by her family physician This was followed by one period She was fairly obese, weight gain was rapid and sudden at the age of 19, married two years but never pregnant, basal metabolic rate was low normal Lipiodol injection of uterus and tubes showed no abnormalities X-ray therapy to ovaries alone was given between Aug 6, 1930, and Sept 11, 1930 Menstruation was re-established one



Fig 1

Fig 1 In this film of the abdominal and pelvic areas we have all three densities illustrated Areas I III and IV show normal soft tissue density, Area V, over the sacrum shows increased or plus density, Area VI over a collection of gas in the bowel, shows a lessened or a minus density

Normal kidneys or psoas muscles, normal bone, and the commonly found collections of gas in the bowel (on a properly taken film) may therefore be considered as standards of the various densities and used as basic guide in the interpretation of such films

If we carefully examine the two psoas muscles on this film (Areas III and IV), it is easy to see that Area III is much wider and its border quite indistinct as compared to Area IV In the absence of evidence of disease in the adjacent bones or joints (on complete x-ray examination), we have considered these findings indicative of retroperitoneal pathology and usually perinephritic abscess such as was found in this case

In this instance the abnormal soft tissue markings are of definite diagnostic value without the use of any special measures some of which might have obscured the difference in the psoas markings

Fig 2 In this film of the unprepared abdomen and pelvis we see three arrows pointing to an area of increased (plus) density in the left pelvic region which, on close examination, showed at least part of one tooth The interpretation of dermoid cyst of the ovary was proven at operation The patient was referred for gastro intestinal examination but the ovarian tumor proved to be the cause of the complaint and no further x ray examination was made These shadows might have been very difficult to interpret, or possibly overlooked, had any opaque material been used



Fig 2

ing some calcium, calcified mesenteric and omental glands, renal and ureteral stones, calcifications occasionally seen in the parenchyma of the kidney, its pelvis and calices, phleboliths along the lower lateral margins of the pelvic outlet, and occasionally ureteral and bladder calculi Less common shadows in this group include calcifications in various organs, as uterus and ovary, especially when the latter contains teeth or other dense elements (Fig 2) One may also be surprised to find forgotten opaque foreign bodies such as Murphy buttons (Fig 3) and bullets

When any of the above mentioned or similar lesions are suspected it is absolutely essential to make use of the preliminary film of the abdomen or a pair of stereoscopic films may be made if desired to enable one to make a survey of the entire area before any further examination is attempted The value of this preliminary film of the abdomen in the chronic as well as in the acute cases is not sufficiently appreciated by the average practitioner of medicine The dilated coils of the acutely obstructed small bowel filled with gas cast a minus density shadow (Fig 4) The

THE VALUE OF THE PRELIMINARY FILM WITHOUT OPAQUE MEDIA IN THE DIAGNOSIS OF ABDOMINAL CONDITIONS

By JAMES F. KELLY, M.D., F.A.C.R., Professor of Radiology, and D. H. DOWELL, B.S., M.D., Assistant in Radiology, Creighton University School of Medicine, Omaha, Nebraska

THE practice of medicine cannot be successful and progressive if one is forced to blindly follow routine procedures and fixed clinical laws. Nevertheless, when one considers the x-ray examination of the abdomen and pelvis and their contents, he is inclined to become dogmatic and insist on a clinical law which would require a preliminary film of any area containing an organ or system which later may be changed in appearance by the use of some special preparation for x-ray demonstration. At the present time, due to the progress made in the use of special methods of demonstrating certain structures, there has been a swing away from the use of films of the unprepared¹ abdomen and pelvis. Very often the only method of examination the clinician seems to care about is one in which some special preparation is necessary, and usually he orders the examination along these lines. Unfortunately this plan is very often followed by the radiologist, and in the special preparation important shadows such as opaque gallstones are obliterated, and the examination is worse than useless, it is misleading. There should be a clinical law requiring that preliminary films be taken of any organ or area in which any contrast method of examination is to be employed, as often a preliminary film of the area would bring out shadows of great diagnostic value which are later obscured by the use of any contrast medium.

The value or the necessity of a routine preliminary film of the abdomen of the unprepared patient in the biliary, gastrointestinal, or genito-urinary x-ray examination will be evident as one becomes more experienced in the x-ray examination of the

structures contained in these systems. This preliminary film would still be necessary even if the clinician were always able to distinguish between the patient with gall-bladder trouble and the one having a gastro-intestinal lesion, or the one having a gastro-intestinal lesion and the one having some pathology in the urologic tract, but such is not the case. Often, after the most careful history and physical examination, he is still in doubt as to which system is involved. The problem of the acute abdomen is also a hazardous one for the surgeon, internist, general practitioner, radiologist, and occasionally for even some of the other specialties, particularly the urologist, and less frequently the gynecologist and obstetrician.

Speaking technically, there are two types of examinations employed for the unprepared abdomen and pelvis, first the fluoroscope, second the use of the film, or these methods may be combined. Both methods have their indications and contra-indications, advantages and disadvantages. In the main, the density of the solid soft tissues of the kidney and psoas muscle of the unprepared abdomen may be taken as a standard density because they are of fairly uniform density which we designate as "normal density."

Gas in the tissues, as commonly found in the intestinal tract, casts a shadow somewhat darker than the surrounding more solid soft parts, in other words, it is less dense than normal density, and these shadows will be termed "minus density" (Fig 1). In certain situations minus density shadows are of great diagnostic significance. On the other hand, numerous pathologic conditions obstruct the rays to a greater extent than the normal solid soft parts, and these areas are of greater density and are referred to as "plus density." In this latter group fall gallstones contain-

¹ *Unprepared* refers to those patients in whom special aid is not employed to bring out tissue differentiation. *Prepared* refers to those patients in whom some special preparation such as the use of contrast media as barium, gas injection, lipiodol, thorotrast, etc. is used.



Fig 5

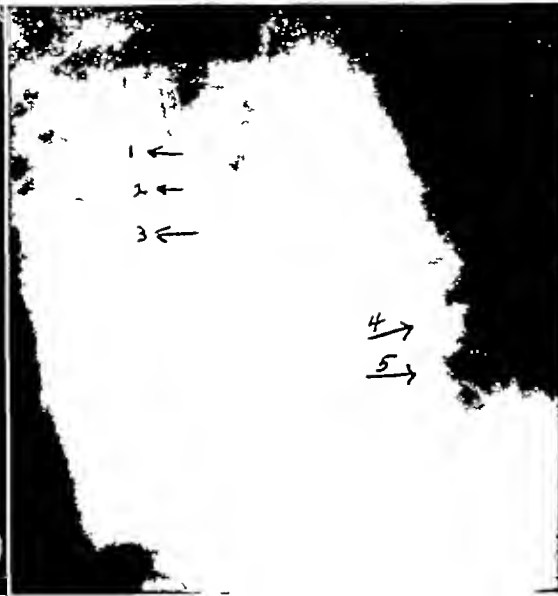


Fig 6

Fig 5 In this illustration the arrows 1 and 2 point toward the right and left diaphragms respectively, each of which shows as a line of increased density reaching to the lateral chest wall. Immediately beneath the elevated diaphragm on each side are areas of lessened (minus) density due to free gas. Arrow 3 points toward a fluid level, the free gas and free fluid in this region are usually found in a subphrenic abscess while the free gas under the left diaphragm means free air in the peritoneal cavity, and the findings under the two diaphragms are characteristic of perforated intestine. This is a preliminary or survey film taken with patient standing. The usual prone film was taken and showed nothing.

It is absolutely essential if free air is suspected under either diaphragm that the patient be taken standing or sitting up. The information gained makes the procedure worth the added danger to the patient.

Since we know from our work with pneumoperitoneum that gas is readily absorbed it is well to bear in mind that if no free gas is demonstrable it is not absolute evidence that there has been no perforation especially if some time has elapsed between the onset of symptoms and the time the roentgenogram was made.

Peritonitis due to gas-forming organisms may also give rise to free gas in the abdomen.

Fig 6 In this illustration we have the cardinal findings of a subphrenic abscess. The right diaphragm (arrow 1) is elevated, thickened and lies over an area of lessened (minus) density due to a collection of free gas (arrow 2) which in turn lies immediately above some free fluid (arrow 3) above the liver. The normal diaphragm (arrow 4) and the normal collection of gas in the cardiac end of the stomach may be seen on the left side. Note the difference in the position of the two diaphragms also the abnormal thickening on the right.

tion, atypical ureteral stones, and similar cases, that we have come to believe it should be the routine in examinations of the trunk in which a contrast medium may be used later or in which surgery is contemplated.

In the summer, when the heat is extreme over a long time and the use of cold drinks and cold foods is so prevalent that many intestinal upsets occur, some of which result in acute partial obstructions, we are called upon to x-ray many acute abdomens. Our first and very often our only procedure is a flat film of the abdomen. It is surprising—the number of small bowel dilatations that we find and how quickly they respond

to therapy, the principal item of which is the use of the Wangenstein (Fig 4) suction tube, draining the upper intestinal tract through the mouth.

Another place in which we feel that a preliminary film of the abdomen is an essential part of the routine is in all cases of suspected acute appendicitis. The occasional demonstration of low ureteral calculus in these cases leads one to have great respect for this simple procedure, and we believe that in time—and by that, we mean before long—it will be unfair and unjust to any patient to do a laparotomy on him if the diagnosis is at all in doubt, without this preliminary film of the unprepared patient.



Fig 3



Fig 4

Fig 3 In this film the arrow points to an area of increased (plus) density which proved to be a Murphy button which had been in the small bowel for an unknown length of time. Twenty three years before it had been used in surgical repair on a gastric lesion and as the patient remained in good health for several years he forgot the type of operation performed and this metallic foreign body was overlooked during two recent gastro-intestinal x ray examinations. The patient is a physician.

Fig 4 In this illustration the area indicated by the arrow and the letter A is the gas filled stomach while below this are several coils of small bowel lying transversely across the abdomen indicated by the letter B. The close set haustral markings in the walls of this distended gut serve to identify it as small bowel. The Wangenstein tube may be seen entering the stomach just below the upper letter A and passing upward along the greater curvature of the stomach.

The use of the barium meal is contra indicated at this time for this patient.

characteristic haustral markings of the small intestine are visible and sufficiently significant in such cases so that it is unnecessary to resort to the use of a barium meal which may greatly embarrass an already distended gut. We never use a barium meal in the acute abdomen without first having a preliminary film, and if a distended small bowel is present, no barium is used, if the large bowel is distended, a barium enema is given. In rare instances when it is necessary to use barium by mouth, a very small amount of the barium meal will suffice.

In our opinion all examinations of the gastro-intestinal tract, even in chronic cases, should begin with at least preliminary films of the gall bladder or, as stated before, the large preliminary film including the entire abdomen. If a perforation of

the intestine with free air or fluid in the peritoneal cavity (Fig 5) is present or a subphrenic abscess is suspected (Fig 6), a film in the upright position must be taken. If the patient is unable to stand, he may sit up and the film must include the lower lung-fields, at least the full shadows of the diaphragms. This takes but little time, and the expense is not at all prohibitive.

If the large preliminary film of the abdomen is not taken, we usually take two of the gall-bladder area for comparison with later films and to compare with each other, before any opaque substance is given, as frequently one film leaves us with a very poor idea as to whether or not there are any calculi in the gall bladder. The large preliminary film of the unprepared abdomen has been of such great help to us, particularly in cases of partial intestinal obstruc-

pneumonia without sufficient pulmonary consolidation to cast significant x-ray shadows, but after observing two cases which were suspected of pneumonia, but in which appendicitis was also seriously considered, go on to demonstrate consolidation on the 24-hour observation, the lung being entirely negative at the time of the first observation, we are convinced that occasionally one may not have sufficient pulmonary change in an early pneumonia to permit of the absolute diagnosis on the fluoroscope. Therefore, if the case is very early—a matter of some hours—one should not be too emphatic in his opinion that pneumonia is not a possibility. A film of the chest would be, of course, more accurate in showing a slight change than would the fluoroscope, and in certain cases both methods of x-ray examination should be employed, in the very early cases at least a 12-hour interval might be allowed to observe what change, if any, has taken place in the lung shadows.

So much for the use of the fluoroscope and preliminary film in the acute abdomen without the use of contrast media in the diagnosis of acute abdominal conditions. Consideration of the use of contrast medium has been purposely left to the last because it is but seldom used in the acute cases.

If the gall bladder is suspected of being the major cause of complaint, of course we use the gall-bladder dye as a routine measure after taking preliminary films of the gall-bladder area. We use the oral method of dye examination, and if the shadow is absent or indistinct on the first day's examination, we give another dose of the dye that evening and re-examine the patient the next day. This gives us very distinct shadows in many instances in which the single dose of dye has given us no—or but a doubtful—shadow. The preliminary films of the gall bladder without dye will, as everyone knows, show only the opaque or calcium-containing gallstones and since these make up such a small percentage of the total number of gallstones, the films without the dye are of limited value only.

However, since the preliminary films of the gall bladder show the opaque stones when present, and the dye in the functioning gall bladder serves to outline the non-opaque stones when present, as well as to assist in localizing opaque and non-opaque suspicious shadows in the gall-bladder area, one is well able at the present time to determine whether or not the patient has gallstones, particularly if the gall bladder is functioning.

The value of the Graham-Cole procedure cannot be overestimated and is best appreciated by the early workers who struggled hard to demonstrate an occasional calcium stone, while to-day it is a daily occurrence with the aid of the dye to determine whether or not a gall bladder is functioning, and often, when functioning, to show numerous non-opaque stones. At the present time the full use of the x-ray and the Graham-Cole method is an essential step in the diagnostic procedure if the gall bladder is at all suspected.

SUMMARY

To summarize briefly, one must keep in mind that both the gall bladder and lower intestinal tract should have a preliminary film of the suspected area before any opaque medium is given to the patient by mouth or intravenously, or barium or gas given *per rectum*. After the preliminary film one may follow a routine form of examination or vary it to suit the requirements of the special case. One must keep in mind that opaque shadows in the gall bladder may be obscured by administering opaque gall-bladder dye before the preliminary film is taken, on the other hand, cholesterol or non-opaque stones not evident on the first film may be brought into plain view by the use of the opaque gall-bladder dye in a functioning gall bladder. One may be similarly confused with the use of opaque medium in the kidney, ureter, and bladder regions covering an opaque pathologic shadow before a preliminary film has been taken. The same may also be said concerning the omental calcifications which become confused with the opaque shadow of the



Fig 7

Fig 7 In this illustration we have an obstructed large bowel filled with gas. The course of the gut as indicated by Arrow C and the width of the haustral markings, as indicated by Arrow A, are the significant features and are well shown without any preparatory measures.

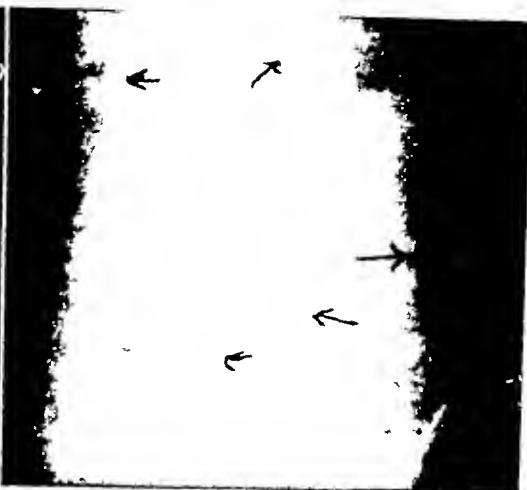


Fig 8

Fig 8 In this illustration we see several small collections of gas above fluid levels—these small gas bubbles are at various levels of the abdomen and are characteristic findings of an obstructed small gut when the film is taken with the patient in the upright position.

The acute distention accompanying obstructions due to various causes, functional and organic, may occasionally be diagnosed by the fluoroscope but are best demonstrated, as before mentioned, by the preliminary film of the abdomen without the use of any opaque substances. In the absence of these dilated coils of small intestine or the wider loops of distended large bowel on the preliminary film, one is justified in concluding that no—or only partial—obstruction is present. The small bowel markings, as seen in the distended gut with acute obstruction, are quite different from the haustral markings of the distended gut which has been partially obstructed over a long period of time. The haustral markings in the acutely obstructed small gut are close together and give one the idea of a herring-bone arrangement (Fig 4). The more chronically obstructed small gut shows possibly a little less distention, and the haustral markings are irregular and a little farther apart, but not so far apart nor so uniform in appearance as the normal haustral markings in the colon. The location and course of this distended small gut are also of diagnostic importance, being more centrally located than the

colon, and its course is usually transversely back and forth across the abdominal field. In the colon the haustral markings are much farther apart, and the width of the large gut (Fig 7), when distended due to obstruction is much greater than normal. Both the large and the small gut are about twice their normal width when distended, making the obstructed small gut about the width of the normal large gut. The identification of the acutely obstructed small gut rests on the numerous close-set haustral markings when taken in the prone position, and multiple small gas bubbles and fluid levels when taken in the upright position (Fig 8). Since the colon when obstructed is about twice its normal width and shows the widely spaced haustral markings, it seems that it should not be confused with the small bowel markings, even though the latter are distended.

The possibility of a pneumonia with predominating abdominal symptoms can usually be definitely settled with a fluoroscopic examination of the chest, as generally there is sufficient early consolidation present to permit one to draw the right conclusions, however, this is not always so. We formerly thought one could not have

CASE REPORTS

MULTIPLE CHONDROMAS

By JOHN DAY PEAKE M D , *Mobile, Alabama*

In presenting the following case of multiple chondroma, I appreciate that cases of chondroma are not uncommon. However, the following case demonstrates a chondroma in one of the long bones of the forearm, which is not a

steal involvement. X-ray examination of the following skull, pelvis, chest, dorsal spine, shoulders, both legs and feet, all revealed no bone changes other than a small area of increased radiability in the lower third of the left tibia, in anterior aspect of left medullary canal. No other destruction or proliferation noted. No elevation of periosteum.

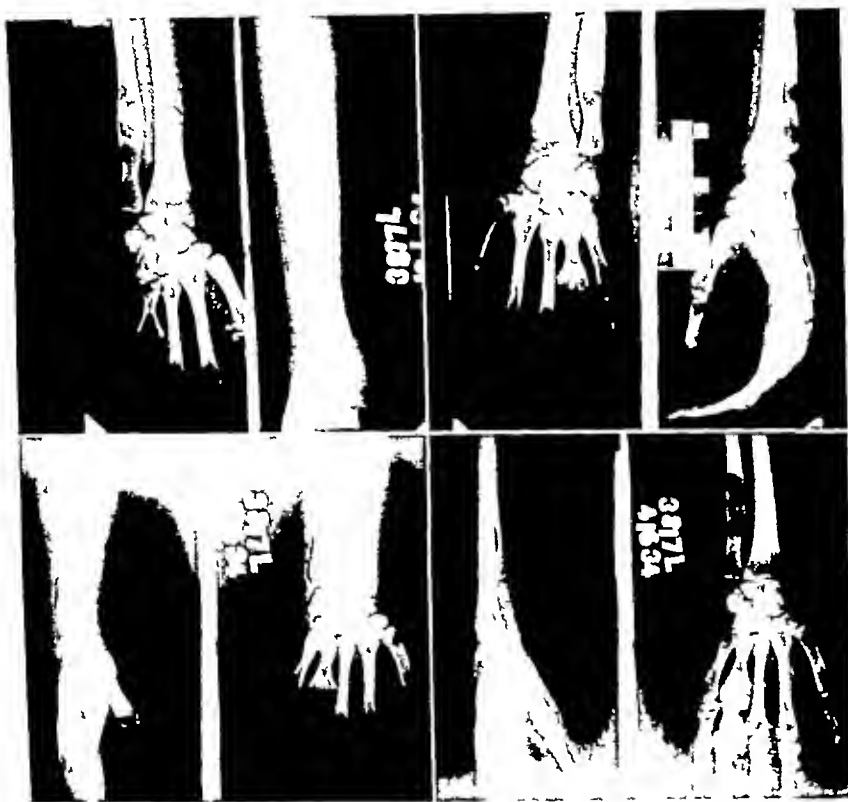


Fig 1 Case of multiple chondromas

common site for such a tumor. This case is of some interest because it was treated with radiation with good results and not by surgery, which form of treatment is so frequently employed in some quarters.

Patient (H M), white female, aged 20 years, apparently in good health. In 1933, while driving an automobile, patient fractured lower third of left forearm. Was treated as a fracture, but no x-rays were taken for several months, and at that time cystic bone changes with trabeculation were noted in lower end of ulna, distal end of fourth metacarpal, proximal phalanges of ring and little fingers. These cystic changes were a thinning of the bone near the epiphyseal line. No destruction and no perio-

osteal involvement. General physical examination did not reveal any gross abnormal findings other than tumefaction of lower third of left forearm, left ring and little fingers.

No abnormal findings in the blood, urine, stool, blood calcium, or phosphorus.

Past history: Usual childhood diseases with no complications. Pneumonia, influenza, tonsils and adenoids, no complications. Left hand, crushed in childhood, apparently healed normally. Family history, irrelevant, menstrual history, normal, system history, normal.

Progress: This patient was given medium doses of x-ray (300-600 r) — 180 kv p, 0.5 mm Cu, 1 mm Al filter, distance 60 cm, port 5X5 at intervals, calcium and vitamin therapy.

small bowel if the barium meal has been given. The demonstration of the distended small gut, when present, is also quite important, lest barium be added to an already overtaxed viscus in cases of partial or complete obstruction. Therefore, to be accurate and thorough, a film of the entire abdomen should be routinely taken before many of the present-day contrast methods of examination are initiated.

The purpose of this short paper is not to bring out anything new or original but to make us more thoughtful in the use of the measures we have at our disposal, and particularly to stress the value of preliminary films of the acute surgical abdomen and also before the usual gall-bladder, gastrointestinal, or genito-urinary examinations are made with the use of any contrast

medium. No attempt has been made to minimize the advantages of contrast methods, and the value of such measures in gall-bladder examinations are shown to offset the formation of such an impression. It is the sequence of the methods to be used which should be given the utmost consideration in every examination lest the wrong method be used first. The only way the proper sequence of methods can possibly be employed is through the co-operation or the teamwork of the various physicians on the case, each one endeavoring to help the other, and not—as is often the case—holding out some important findings just to see how much the other method will reveal. For the good of the patient, frankness and teamwork by all concerned is every physician's duty.

We have watched this patient at intervals for the past three years. The x-rays of the left forearm and hand show a definite increase in bone with a decrease in cystic changes. No change in left tibia. Now the patient apparently is healthy and active, she is careful not to injure her arm.

I am indebted to John C. Hope, M.D., for the opportunity of studying this case.

ANOMALIES OF THE AORTIC ARCH

By MILA J. KINNEY, M.D., ELMER LILJEDAHN, M.D., and RICHARD T. TAYLOR, M.D.,
Los Angeles, Calif.

Anomalies of the aortic arch are not considered rarities but, nevertheless, they present at times problems which are both interesting and important.

In order to appreciate and understand the various anomalies to which the aorta is susceptible one must have a clear understanding of the normal aorta, which as we know, at times varies even within the normal. For

these reasons we are presenting two such interesting cases.

Case 1 A man, aged 28, was sent in for gastro-intestinal examination on Nov. 11, 1936. There were no symptoms referable to pressure on the esophagus. However, on close questioning he said he had noticed, for as long as ten years, an occasional sensation of obstruction in swallowing. The normal aortic shadow on the left was absent, with a decided prominence on the right side. In the first oblique position, the esophagus could be seen taking a course anterior to the aorta. There was no evidence of an aneurysmal dilatation or the presence of syphilis.

Diagnosis Anomaly of the aortic arch.

Case 2 A man, aged 40, complained of no symptoms referable to pressure on the esophagus, and careful questioning could not break down this statement. As in Case 1, the normal aortic knob on the left was absent but was seen clearly on the right. In the lateral position, the esophagus can be seen displaced anteriorly at the level of the arch.

Diagnosis Right-sided aortic knob.

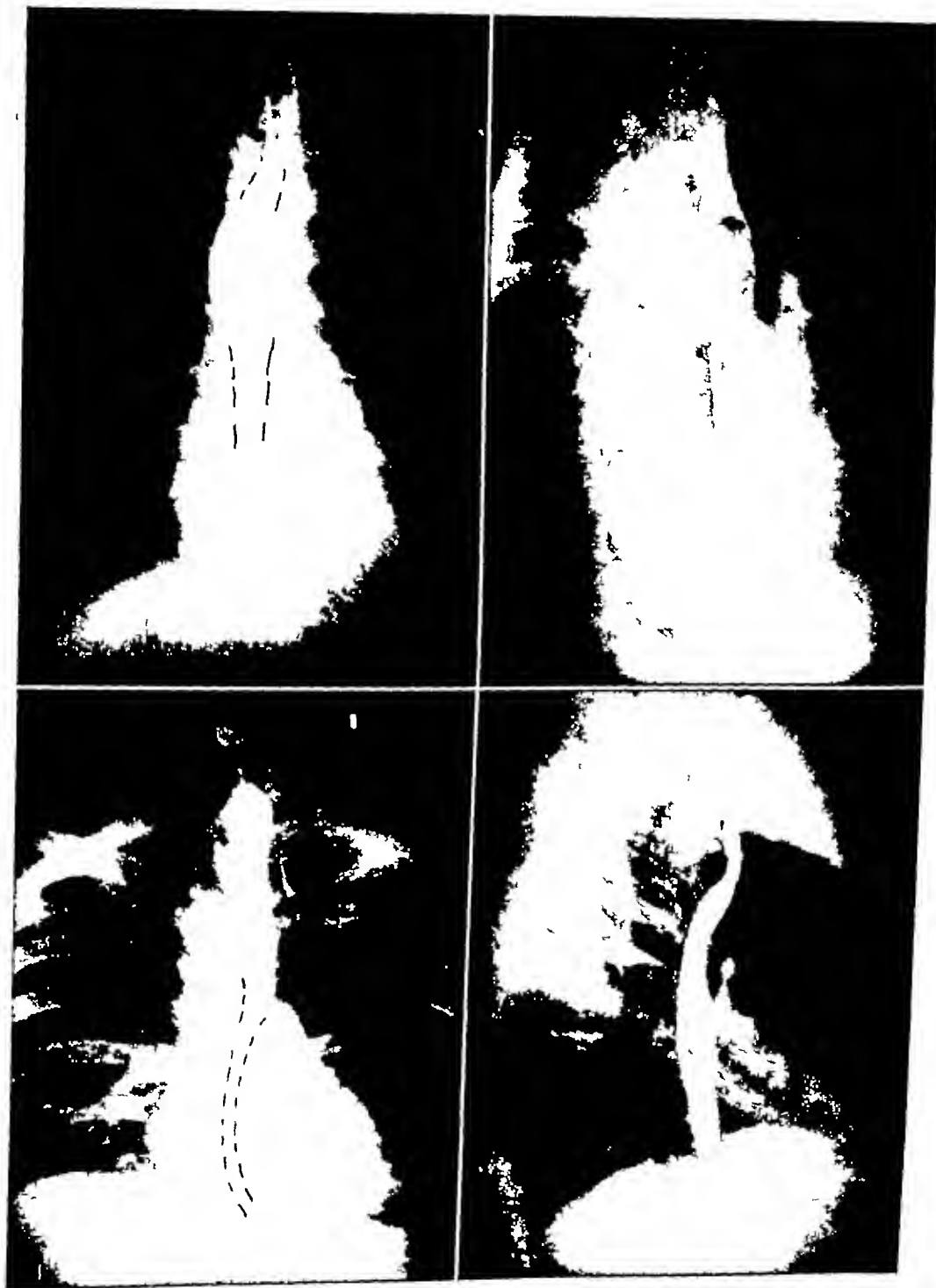


Fig 1 (upper left) Case 1 Fig 2 (upper right) Case 1 Fig 3 (lower left) Case 2 Fig 4 (lower right) Case 2 (With Anomalies of Aortic Arch See next page)

MASSACHUSETTS

See New England Roentgen Ray Society

MICHIGAN

DETROIT X-RAY AND RADIUM SOCIETY *President*, C C Birkelo, M D, Herman Keifer Hospital, *Vice-president*, E W Hall, M D, 10 Peterboro St, *Secretary-treasurer*, E R Witwer, M D, Harper Hospital Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society Bldg

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS *President*, J C Kenning, M D, 1536 David Whitney Bldg, Detroit, *Vice-president*, A W Chase, M D, 133 Toledo St, Adm'n, *Secretary-treasurer*, C S Davenport, M D, 609 Carey St, Lansing

MINNESOTA

MINNESOTA RADIOLOGICAL SOCIETY *President*, Walter H Ude, M D, 78 S 9th St, Minneapolis, *Vice-president*, Leo G Rigler, M D, University Hospitals, Minneapolis, *Secretary-treasurer*, Harry Weber, M D, 102 Second Ave, S W, Rochester Meetings quarterly

MISSOURI

THE KANSAS CITY RADIOLOGICAL SOCIETY *President*, L G Allen, M D, 907 N 7th St, Kansas City, Mo, *Secretary*, Ira H Lockwood, M D, 306 E 12th St, Kansas City, Mo Meetings last Thursday of each month
THE ST LOUIS SOCIETY OF RADIOLOGISTS *President*, Joseph C Peden, M D, 634 N Grand Blvd, *Secretary*, W K Mueller, M D, 607 N Grand Blvd Meetings fourth Wednesday of each month

NEBRASKA

NEBRASKA STATE RADIOLOGICAL SOCIETY *President*, Howard B Hunt, M D, 4740 Hickory St., Omaha, *Secretary*, D Arnold Dowell, M D, 117 S 17th St, Omaha Meetings first Wednesday of each month at 7 P M in Omaha or Lincoln

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut) *President*, A E O'Connell, M D, 390 Main St, Worcester, Mass, *Secretary*, E C Vogt, M D, 300 Longwood Ave, Boston Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library

NEW HAMPSHIRE

See New England Roentgen Ray Society

NEW JERSEY

NEW JERSEY STATE RADIOLOGICAL SOCIETY *President*, W W Maver, M D, 532 Bergen Ave, Jersey City, *Vice-president*, J D Tidaback, M D, 382 Springfield, Summit, *Secretary*, P S Avery, M D, Middlesex General Hospital, New Brunswick Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by President

NEW YORK

BUFFALO RADIOLOGICAL SOCIETY *President*, John Barnes, M D, 875 Lafayette Ave, *Vice-president*, W L Mattick, M D, 290 Highland Drive, *Secretary-treasurer*, J S Gian-Franceschi, M D, 610 Niagara Street Meetings second Monday evening each month

CENTRAL NEW YORK ROENTGEN-RAY SOCIETY *Secretary*, Carlton F Potter, M D, 425 Waverly Ave, Syracuse

ROCHESTER ROENTGEN-RAY SOCIETY *Chairman*, Jos H Green, M D, 277 Alexander St, *Secretary*, S C Davidson, M D, 277 Alexander St Meetings at convenience of committee

NORTH CAROLINA

RADIOLOGICAL SOCIETY OF NORTH CAROLINA *President*, Robert P Noble, M D, 127 W Hargett St, Raleigh, *Vice-president*, A L Daughtridge, M D, 144 Coast Line St, Rocky Mount, *Secretary-treasurer*, Major I Fleming, M D, 404 Falls Road, Rocky Mount Meetings with State meeting in May, and meeting in October

OHIO

RADIOLOGICAL SOCIETY OF THE ACADEMY OF MEDICINE (Cincinnati Roentgenologists) *President*, George Benzeng, M D, St Elizabeth Hospital, Covington, Ky, *Secretary-treasurer*, Justin E McCarthy, M D, 707 Race St, Cincinnati, Ohio Meetings held third Tuesday of each month

PENNSYLVANIA

PENNSYLVANIA RADIOLOGICAL SOCIETY *President*, W E Reiley, M D, Clearfield, *First Vice-President*, Charles S Caldwell, M D, 520 S Aiken Ave, Pittsburgh, *Second Vice-president*, Louis A Milkman, M D, Medical Arts Bldg, Scranton, *Secretary-treasurer*, Lloyd E Wurster, M D, 416 Pine St., Williamsport, *President-elect*, Sydney J Hawley, M D, Geisinger Memorial Hospital, Danville Annual meeting, May 21-22, Erie

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALENDAR

MEETINGS FALLING BETWEEN THE DATES OF JULY 15 AND AUGUST 31

July 15-17 Denver Radiological Club mid-summer meeting at Shirley-Savoy Hotel, Denver, Colo

Editor's note—Will secretaries of societies please co-operate with the Editor by supplying him with information for this page

CALIFORNIA

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY *Chairman*, John D Lawson, M D, 1306 California State Bldg, Sacramento, *Secretary*, Karl M Bonoff, M D, 1930 Wilshire Blvd, Los Angeles Meets annually with California Medical Association

LOS ANGELES COUNTY MEDICAL ASSOCIATION, RADIOLOGICAL SECTION *President*, D R McColl, M D, *Vice-president*, John F Chapman, M D, *Secretary*, E N Liljedahl, M D, *Treasurer*, Henry Snure, M D Meets every second Wednesday of month at County Society Building

PACIFIC ROENTGEN CLUB *Chairman*, Raymond G Taylor, M D, 1212 Shatto St., Los Angeles, *Secretary*, L Henry Garland, M D, 450 Sutter St, San Francisco

COLORADO

DENVER RADIOLOGICAL CLUB *President*, W Walter Wasson, M D, 246 Metropolitan Bldg, *Vice-president*, Ernst A Schmidt, M D, Colorado General Hospital, *Secretary*, Nathan B Newcomer, M D, 306 Republic Bldg, *Treasurer*, Leonard G Crosby, M D, 366 Metropolitan Bldg Meets third Tuesday of each month at homes of members Midsummer Conference, Shirley-Savoy Hotel, July 15-17

CONNECTICUT

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY *Chairman*, Kenneth K Kinney, M D, 29 North Street, Willimantic, *Vice-chairman*, Francis M Dunn, M D, 100 State Street, New London, *Secretary-treasurer*, Max Chman, M D, 242 Trumbull St, Hartford Meetings twice annually in May and September

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society

FLORIDA

FLORIDA STATE RADIOLOGICAL SOCIETY *President*, Gerald Raap, M D, 168 S E First St, Miami, *Vice-president*, H O Brown, M D, 404 First Nat'l Bank Bldg, Tampa, *Secretary-treasurer*, H B McEuen, M D, 126 W Adams St, Jacksonville

ILLINOIS

CHICAGO ROENTGEN SOCIETY *President*, David S Beilin, M D, 411 Garfield Ave, *Vice-president*, Chester J Challenger, M D, 3117 Logan Blvd, *Secretary treasurer*, Roe J Maier, M D, 7752 Halsted St Meets second Thursday of each month, September to May, except December

ILLINOIS RADIOLOGICAL SOCIETY *President*, Ivan Brouse, M D, 316 W State, Jacksonville, *Vice-president*, Cesar Gianturco, M D, Carle Hospital Clinic, Urbana, *Secretary-treasurer*, Edmund P Halley, M D, 968 Citizens Bldg, Decatur Meetings quarterly by announcement

ILLINOIS STATE SOCIETY, SECTION OF RADIOLOGY *President*, Roswell T Pettit, M D, 728 Columbus St, Ottawa, *Secretary*, Ralph G Willy, M D, 1138 N Leavitt St, Chicago Eighty-seventh annual meeting at Peoria, May 18-20

INDIANA

INDIANA ROENTGEN SOCIETY *President*, J N Collins, M D, 23 E Ohio St, Indianapolis, *President elect*, Stanley Clark, M D, 108 N Main St, South Bend, *Vice-president*, Juan Rodriguez, M D, 2903 Fairfield Ave, Fort Wayne, *Secretary-treasurer*, Clifford C Taylor, M D, 23 E Ohio St, Indianapolis Annual meeting in May

IOWA

THE IOWA X-RAY CLUB Holds luncheon and business meeting during annual session of Iowa State Medical Society

MAINE

See New England Roentgen Ray Society

MARYLAND

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION *Secretary*, H E Wright, M D, 101 W Read St, Baltimore Meetings each Monday night

EDITORIAL

LEON J. MENVILLE, M.D., Editor

HOWARD P. DOUB, M.D., Associate Editor

GROUP HOSPITALIZATION¹

Group hospitalization, by its very name, connotes that the relationship is one of direct arrangements between hospitals and groups and that the use of hospital facilities alone is the service bargained for. Group hospitalization, then, is a plan whereby a hospital or an association of hospitals contracts with classified groups of persons to furnish hospital care when needed in return for the periodic payment or prepayment of a stipulated sum by every member of the group. A *bona fide* group hospitalization plan should exclude all professional or medical services of physicians or surgeons, pathologists, roentgenologists, physical therapists, anesthetists, and special nurses. Strictly speaking, these plans should deal only with groups of a homogeneous nature (teachers, department store employees, transportation employees, and others) to lessen the problems of collecting subscriptions and securing the enrollment of good risks. However, if a sufficiently large number of individuals can be secured, they are frequently enrolled as a special group at a slightly higher rate.

The principles essential to an effective group hospitalization plan were outlined in a report of the experience of an early plan as follows:²

1 Organization must deal with groups, not with individual risks.

2 Groups must be employed, full-time wage earners. Intermittent employment, such as teaching, nursing, etc., brings much higher actuarial risk.

3 The total number of members—spread in all groups to make the law of averages safely apply—should be at least 3,000 to 5,000.

4 Group hospitalization should give only hospital service and should not in any case give service that in any way competes with the physician's professional service. You have to

depend on your medical staff to protect the hospital from malingering of patients. We have had no loss on this score.

5 We allow the patients belonging to groups full liberty of choice as to the physician treating him in the hospital.

6 A long-time commitment to a fixed rate should be avoided. One of the best by-products of such group policy is that coming to the hospital with the bill already provided for educates patients to be hospital-minded and will increase hospital patronage and eventually bring a higher rate.

7 Different types of employed groups present varying actuarial risks as to sickness and differing desires as to the types of accommodations. For instance, bank employees are better actuarial health risks than laundry employees, but desire better accommodations, so we make the same rate for both groups but contract for different accommodations for each group.

8 In our own hospital we have definitely adhered at all times to the policy of dealing directly with the groups through the employer or other representative, and we have never employed any outside selling organization or middleman representative. We feel that this is far the safer course.

It should be observed that particular emphasis was placed on such matters as the preference for group risks, desirability of full-time employment of members and a minimum number of members, hospital service only, freedom of choice, no fixation of rates or provisions, allowances for different actuarial risks, and no intervening third party.

Perhaps the best method of explaining the bases on which the group hospitalization plan is founded would be to follow a schematic outline of a fictitious plan, as follows: (1) expected enrollment, (2) expected hospitalization, (3) expected costs.

Enrollment estimates are based primarily on the number of gainfully occupied persons in the community. While the estimates of the pro-

¹ Reprinted by permission from *Journal of American Medical Association*, May 29, 1937, 108, 180B.

² Kimball, J. F. *Group Hospitalization*. Trans. Am. Hosp. Assn., 33d Annual Convention, Toronto, Canada, 1931, p. 607.

PHILADELPHIA ROENTGEN RAY SOCIETY
President, Thomas P. Laughery, M.D., Germantown Hospital, *Vice-president*, Elwood E. Downs, M.D., Jeans Hospital, Fox Chase, *Secretary*, Barton H. Young, M.D., Temple University Hospital, *Treasurer*, R. Manges Smith, M.D., Jefferson Hospital. Meeting first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S. 22nd St., 8:15 P.M.

RHODE ISLAND

See New England Roentgen Ray Society

SOUTH CAROLINA

SOUTH CAROLINA X-RAY SOCIETY *President*, Robert B. Taft, M.D., 105 Rutledge Ave., Charleston, *Secretary-treasurer*, Hillyer Rudisill, M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

MEMPHIS ROENTGEN CLUB Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

TENNESSEE STATE RADIOLOGICAL SOCIETY *President*, H. S. Shoulders, M.D., 246 Doctors Bldg., Nashville, *Vice-president*, S. S. Marchbanks, M.D., 508 Medical Arts Bldg., Chattanooga, *Secretary-treasurer*, Franklin B. Bogart, M.D., 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

VERMONT

See New England Roentgen Ray Society

VIRGINIA

RADIOLOGICAL SOCIETY OF VIRGINIA *President*, Fred M. Hodges, M.D., 100 W. Frank-

lin St., Richmond, *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk, *Secretary*, V. W. Archer, University of Virginia Hospital, Charlottesville.

WASHINGTON

WASHINGTON STATE RADIOLOGICAL SOCIETY *President*, H. E. Nichols, M.D., Stimson Bldg., Seattle, *Secretary*, T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

CONNECTICUT

THE CONNECTICUT STATE MEDICAL SOCIETY SECTION ON RADIOLOGY met during the State Society's One hundred and Forty-fifth Annual Meeting at Bridgeport, May 19-20, 1937. George Levene, M.D., of Boston, Mass., presented in the program of the Section of Radiology, on May 19, a paper on "The Value of Roentgenologic Study in the Diagnosis of Heart Disease."

At the business meeting following the program, the officers elected for the coming year were *Chairman*, Kenneth K. Kinney, M.D., Willimantic, *Vice chairman*, Francis M. Dunn, M.D., New London, and re-elected *Secretary-treasurer*, Max Climan, M.D., Hartford.

OHIO

The May meeting of the CINCINNATI RADIOLOGICAL SOCIETY has as its guest M. A. Loebl, M.D., of Zanesville, Ohio, who gave an address on his experimental therapy tube.

George Benzeng, M.D., of Covington, Ky., former *Secretary-treasurer*, of the Radiological Society of the Academy of Medicine, Cincinnati, Ohio, was elected *President*, and Justin E. McCarthy, M.D., of Cincinnati, *Secretary-treasurer*.

Main Lines in Technical or Biological Studies of Radiation Therapy Methods Prof Hans Holfelder, Frankfurt-am-Main, Germany

Important Points in the Roentgen and Radium Therapy of Tumors Prof Hermann Holthusen, Hamburg, Germany

The Development of High Voltage X-ray Tubes at the California Institute of Technology Dr Charles C Lauritsen, Pasadena, California, U S A

Production and Biological Effects of Neutrons Dr Ernest O Lawrence, Berkeley, California, U S A

The Radiological Evaluation of the Size and Form of the Heart Prof Gian Giuseppe Palmieri, Bologna, Italy

The Use of the Roentgen Rays in the Diagnosis and Treatment of Tumors of the Bladder Dr George E Pfahler, Philadelphia, Pennsylvania, U S A

Physical and Biological Dosage Prof Mario Ponzio, Turin, Italy

Movements of the Esophagus, Stomach, Duodenum, and Ileum as Revealed by Cineradiographic Films Dr Russell J Reynolds, London, England

Diagnosis, Pathology, and Roentgen Treatment of Peritendinitis Calcarea Dr Carl Sandström, Stockholm, Sweden

Cerebral Cystography and Cisternography Prof Arthur Schüller, Vienna, Austria

Teleroentgentherapy Dr Felix Sluys, Brussels, Belgium

Roentgen Kymography as a Diagnostic Help Prof Pleikart Stumpf, Munich, Germany

The Production of Penetrating Radiations by Means of Electrostatic Generators Dr Robert G Van de Graaff, Cambridge, Massachusetts, U S A

Bronchial Carcinoma, A Roentgen-pathological Study Dr Nils Westermark, Stockholm, Sweden

In addition to the above subjects, there will be reports from Austria, France, Germany, Great Britain, Italy, and the United States on the present status of education and organization in radiology. During these sessions, there also will be reports by the Chairmen of the International Committee on Radiological Units and the International Committee on Protection. At a special afternoon session, Dr Russell J Reynolds, of London, and Dr Maurice Van de Maele, of Brussels, will give reports and demonstrations of the indirect and direct methods of cinematography.

III Three evening sessions of the Congress, namely, Tuesday, Wednesday, and Thursday, are devoted to the three special annual lectures given under the auspices, respectively, of the American Radium Society, The American Roentgen Ray Society, and The Radiological Society of North America. Dr Douglas Quick, of New York City, will deliver the Janeway Lecture on "Carcinoma of the Larynx", Dr George E Pfahler, of Philadelphia, will deliver the Caldwell Lecture on "The Treatment of Carcinoma of the Breast," and Dr George W Holmes of Boston, the Carman Lecture on "The Development of Post-graduate Teaching in Radiology."

IV Educational sessions which were announced in this Journal in the March and April numbers will be held from 8 00 to 9 00 A M on the mornings of Tuesday, Wednesday, Thursday, and Friday, September 14 to 17, inclusive. These courses are open to all members of the Congress but members must register for the course which they desire to take. The courses are being filled very rapidly and anyone who wishes to take one of them should register at once.

V The afternoon sessions of the Congress, Tuesday, September 14, to Friday, September 17, inclusive, are organized in the following Sections

- Section I A, Roentgen Diagnosis,
Chairman, Dr James T Case
- Section I B, Roentgen Diagnosis,
Chairman, Dr Charles A Waters
- Section I C, Roentgen Diagnosis,
Chairman, Dr Fred M Hodges
- Section II A, Radiotherapy,
Chairman, Dr Albert Soiland
- Section II B, Radiotherapy,
Chairman, Dr B P Widmann
- Section II C, Radiotherapy,
Chairman, Dr A U Desjardins
- Section III, Radiophysics,
Chairman, Dr G Failla
- Section IV, Radiobiology,
Chairman, Dr Francis Carter Wood
- Section V, Electrolgy and Light Therapy,
Chairman, Dr Norman E Titus

It is impossible in this brief notice to list the papers which will be presented before the Sections. Leading workers from every country in the world will present papers on diagnosis, therapy, radiophysics, radiobiology, and electrolgy on every important subject in the entire field of radiology. The time limit for

portion of employed groups that will be enrolled vary all the way from 6 to 50 per cent, it is estimated that about 10 per cent will become subscribers (the enrollment of dependents will not be considered, for the sake of simplicity) For a community of 100,000 employed persons it would therefore be estimated that 10,000 persons would subscribe to the plan

The expected hospitalization will necessarily vary according to the benefits and limitations of the contract and the type of community, but it is generally accepted that about one patient day per member annually will be the hospitalization experience Accordingly, it is expected that about 10 per cent of the membership will be hospitalized for an average stay of ten days In other words, for the membership of 10,000, about 1,000 persons would be hospitalized for a total period of 10,000 days each year

In the determination of the costs, a flat sum of, say, \$6 per member is estimated to be adequate to pay for the average patient day cost, including allowances for bed and board, operating room, anesthetic, routine laboratory services, and routine medicines, \$3 per member is allowed for the cost of administration, sales and reserves, and a \$1 enrollment fee is charged for initial recording or to cover promotional expenses The total cost to the subscriber, for the first year, would be \$10

Under the fictitious plan, then, the income from the 10,000 subscribers would be \$100,000 The expected costs of hospitalization would be \$60,000 (\$6 per patient day for 10,000 days) The difference between this anticipated liability and the total revenue, or \$40,000, would be available for all other costs Roughly, the administrative costs are expected to be 10 per cent of the total income and the promotional and sales costs 20 per cent, or a total of \$30,000 Finally, the remaining \$10,000 would be utilized to create reserves and a surplus

In an abruptly simple form, these are the fundamental factors on which the group hospitalization plan is based No one plan would be organized exactly according to the method outlined, but, while the percentages would vary or the costs might be allocated in a different proportion, each group hospitalization plan is formulated approximately on the bases indicated

Even within this more uniform concept of what a group hospitalization plan is, there seem to be four different types of plans (1) single hospitals not employing sales agencies, (2) non-commercial associations or groups of

hospitals not employing sales agencies, (3) a sales agency contracting with a single hospital, and (4) commercial associations or sales agencies contracting with several hospitals

NOTE—This is the fifth of a series of articles on Group Hospitalization, prepared by the Bureau of Medical Economics of the Association, which is to be published weekly in the "American Medical Association Organization Section" When completed, the series will be available in reprint form on request at the headquarters of the Association

ANNOUNCEMENTS

PROGRAM OF THE FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

Sept 13 to 17, 1937

The program of the Fifth International Congress of Radiology is now complete It has been arranged under the following divisions

I Opening session on Monday evening, September 13, at which addresses will be delivered by Dr William J Mayo, Dr Gösta Forssell, Dr H R Schunz, and Dr A C Christie

II Four full sessions of the Congress occupying the entire forenoons from Tuesday to Friday, inclusive The following is a partial list of authors and subjects for these general sessions

The Production of X-rays of Very Short Wave Length, Dr William D Coolidge, Schenectady, New York, U S A

Ionization by High Voltage X-rays and Gamma Rays Dr Arthur H Compton, Chicago, Illinois, U S A

Cancer of the Larynx Dr Henri Coutard, Paris, France

Racial Variations in the Incidence of Carcinoma. Dr Max Cutler, Chicago, Illinois, U S A, and Sir George Lenthal Cheatle, England

The Role of the Autonomous Movements of the Gastro-intestinal Mucous Membrane in Digestion Prof Gösta Forssell, Stockholm, Sweden

The Treatment of Hodgkin's Disease by Radiotherapy Dr René Gilbert, Geneva, Switzerland

Luncheon, Round Table Discussion of Therapeutic Radiology
Sanford Withers, M D, presiding, Denver

There will be scientific and commercial exhibits

"The Denver Radiological Club wishes to call attention to the Rocky Mountain Medical Conference, sponsored jointly by the State Medical Societies of Colorado, New Mexico, Utah, and Wyoming, to be held in Denver, July 19, 20, and 21, 1937. An outstanding program will be offered by clinicians and teachers of international reputation. Physicians attending our radiological meeting should remain in Denver a few additional days for this later Conference, which will be open to all members of their respective state medical societies at a nominal registration fee."

THE AMERICAN COLLEGE OF PHYSICIANS

The Twenty-second Annual Session of the American College of Physicians will be held in New York City, with headquarters at the Waldorf-Astoria Hotel, April 4-8, 1938.

Dr James H Means, of Boston, is President of the College, and will have charge of the program of general scientific sessions. Dr James Alex Miller, of New York City, has been appointed General Chairman of the Session, and will be in charge of the program of clinics and demonstrations in the hospitals and medical schools and of the program of Round Table Discussions to be conducted at headquarters.

A MEMBER HONORED

A former President of the Radiological Society of North America, Arthur W Erskine, M D, of Cedar Rapids, Iowa, has been chosen President elect by his State Medical Society, to succeed Edward M Meyers, M D, the president incumbent.

All of Dr Erskine's friends congratulate him upon this new honor, added to those he has already held. He is a thorough scientist, a charming and accomplished gentleman, and merits the confidence of his colleagues.

IN MEMORIAM

J D SOUTHARD, M D, 1861-1937

Death claimed J D Southard, M D, widely known physician of Fort Smith, Ark., at his home, Sunday, May 9, after a long illness.

A graduate of the University of Louisville Medical School, Dr Southard was a pioneer in the use of x-ray in the treatment of tuberculosis of the lungs and bones. He read a paper before the Arkansas Medical Society on the "Control of Tuberculosis. A Problem for the United States Government," which was presented in the United States Senate, and by unanimous consent of that body was made a public document and published by the government. He was a fellow of the American Medical Association, a member of the Radiological Society of North America, of which at one time he held office, and a fellow of the American College of Surgeons.

He served in many capacities in the city, county, state, and National governments, acting as medical examiner for four years under the Cleveland administration. For eighteen years he was president of the Fort Smith board of health. Dr Southard was one of the founders of the first hospital in that city, and was also a member of its staff, and was active in the work of the Arkansas Tuberculosis Sanatorium.

Dr Southard died at the age of 76 years, after a long illness. He suffered from a metastatic cancer of the right breast from finger epitheliomas.

BOOK REVIEWS

TRAITE DE CHIRURGIE ORTHOPEDIQUE (Volume II) By L OMBREDANNE, Professeur de clinique chirurgicale infantile et orthopedie à la Faculte de medecine de Paris, membre de l'Academie de medecine, chirurgien de l'hôpital des Enfants-Malades, and P MATHIEU, Professeur de clinique de chirurgie orthopedique de l'adulte à la Faculte de medecine de Paris, chirurgien de l'hôpital Cochin. A volume of 1,918 pages. Published by Masson et Cie, Paris, 1937. Price for five volumes, complete, 1,250 francs.

The second of this five-volume system of orthopedic surgery brings, first of all, a brief discussion of some of the affections of the nervous system of prime interest to the orthopedist. There is also a review of vascular affections and

presentation of papers will be adhered to strictly and the programs of the various Sections will be so synchronized that any member may arrange for himself a program which will include papers in all of the Sections

During the month of August, all members of the Congress will receive a preliminary program listing all of the addresses and papers to be presented before the Congress, both in the general sessions and the Sections

Applications for membership are being received in large numbers in the office of the General Secretary, indicating that there will be a large attendance at the Congress. Since the membership fee includes the right to register for one of the educational courses and attendance at all of the scientific and social events, including the final grand banquet on the closing night, it is important for everyone to complete his membership at the earliest possible moment

PRELIMINARY PROGRAM OF THE THIRD MIDSUMMER RADIOLOGICAL CONFERENCE

IN THE ROCKY MOUNTAINS, DENVER

This Conference is sponsored by the Denver Radiological Club. The dates are July 15, 16, 17, 1937. There is no registration fee. This program has been designed to better acquaint the entire medical profession with the uses of radiology in diagnosis and treatment. All meetings are to be held in the Hotel Shirley-Savoy (17th Avenue entrance), Denver.

Thursday, July 15

W. W. Wasson, M.D., presiding, President,
Denver Radiological Club

Address of welcome, A. J. Markley, President,
Colorado State Medical Society, Denver

Symposium on the Breast

Anatomy of the Breast

H. C. Tracy, M.D., Department of Anatomy,
University of Kansas, Lawrence, Kan.

Pathology of the Breast

Frederick C. Narr, M.D., Pathologist, Research Hospital, Kansas City, Mo.

The Roentgen Examination of the Breast

Ira H. Lockwood, M.D., F.A.C.R., Kansas City, Mo.

Benign Lesions of the Breast

James E. Stowers, M.D., F.A.C.S., Kansas City, Mo.

The Surgical Treatment of Carcinoma of the Breast

Claude J. Hunt, M.D., F.A.C.S., Kansas City, Mo.

The Radiation Treatment of Carcinoma of the Breast

Lewis G. Allen, M.D., F.A.C.R., Asst. Professor of Radiology, University of Kansas, Kansas City, Kan.

Discussion opened by Henry Schmitz, M.D., Chicago

Joint meeting with the Medical Society of the City and County of Denver, Paul J. Connor, M.D., presiding, President of the Medical Society of the City and County of Denver

Guest Speakers

Leo G. Rigler, M.D., Minneapolis, Minn.
The Roentgen Examination in Preventive Medicine

Henry Schmitz, M.D., Chicago

The Selection of the Form of Treatment in Uterine Myomas

General discussion

Friday, July 16

Recent Advances in Diagnostic Radiology
Ernst A. Schmidt, M.D., Denver

Roentgen-ray Pelvimetry and Cephalometry
Paul C. Hodges, M.D., Chicago

Roentgen Findings in Pleural Effusions
Leo G. Rigler, M.D., Minneapolis

Roentgenologic Studies of the Gastro-intestinal Motor Phenomena

Leon J. Menville, M.D., New Orleans

Luncheon, Round Table Discussion of the Problems of Diagnostic Radiology
Chairman, Frederick E. Diemer, M.D., Denver
The Demonstration of the Crater in Duodenal Ulcer

Paul C. Hodges, M.D., Chicago

Bone Tumors

Leon J. Menville, M.D., New Orleans

Saturday, July 17

Recent Advances in Radiation Therapy
Paul R. Weeks, M.D., Denver

The Diagnosis, Treatment, and Curability of Intra-oral Cancer

Hayes E. Martin, M.D., New York

The Diagnosis and Treatment of Cancer of the Uterus

Henry Schmitz, M.D., Chicago

HOWARD FOX, M D , Professor of Dermatology and Syphilology, New York University A volume of 177 pages with 94 illustrations Published by Charles C Thomas, Springfield, Ill , 1936 Price, \$3 50, cloth

This is a short monograph limited entirely to the consideration of diseases and dystrophies of the nails The book is profusely illustrated, most of these illustrations and enlargements are excellent The author discusses the anatomy and histology of the nails, and takes up the dystrophies and diseases which are peculiar to the nails and those which affect the nails as part of a systemic dermatosis or other disturb-

ance The most common affections, which are the occupational paronychia, psoriasis, and fungus infections, are considered in detail Inasmuch as the treatment of diseases of the nails represents one of the most difficult therapeutic problems that confronts the dermatologist, the author provides liberally from his experience, giving valuable hints It is stated that one of the most useful agents available for the treatment of diseases of the nails is the roentgen ray and this phase of the subject is discussed in a separate chapter The book is an excellent brief reference work for the general practitioner

of those phases of hematology interesting to the orthopedist, including a chapter on transfusions

The authors then present a chapter on roentgen diagnosis in orthopedic surgery followed by discussions on all types of apparatus, including plaster and celluloid splints. An extensive review of various types of massage and physiotherapy is then given. These portions of the book are well illustrated and would serve as an excellent guide to any one interested in such phases of treatment.

The remaining portion of the volume then deals with the spine, or, at least, the cervicodorsal and the dorsolumbar portion of the spine.

A discussion of the physiology of the spine in general is first given, followed by a review of the technic of spinal puncture, the roentgenologic technic of the spine, and a discussion of treatment of affections of the spine dealing in a general way with types of fixation for the spine and operative procedures used in surgery of the spine.

In discussing the cervical spine a very excellent review of congenital malformations is given, particularly the Klippel-Feil syndrome, cervical ribs, and torticollis, fractures and dislocations of the atlas and axis, as well as the lower cervical vertebrae, are adequately discussed.

In discussing the dorsolumbar spine a much more extensive review is given, including the congenital anomalies, osteochondritis, sacralization, spondylolisthesis, kyphosis, scoliosis, fractures, and arthritis. A chapter on intervertebral discs is inserted, and syphilis, osteomyelitis, and Pott's disease are discussed.

The chapter on scoliosis is well arranged and a most complete discussion of the widely recognized etiologic theories is presented. We find in it various phases of examination, described in great detail. In the discussion of treatment the authors have not presented the various up-to-date methods used in the United States. We are disappointed to find the method of Abbot described in considerable detail, and the turnbuckle jacket method of Brewster and Lovett described as the method of "John and Lovett." In the operative treatment no mention is made of Lowman's method and the work familiar to us as the product of Hibb's clinic is not well presented.

In connection with the discussion on scoliosis a chapter on various types of exercise suitable for scoliosis is presented.

Fractures of the spine are well discussed and the method of Böhler treatment recommended. In the traumatic lesions of the intervertebral disc the authors refer to the works of Dandy and of Stookey along this line but fail to mention Mixer and Barr, who, to our best knowledge, have done more to modernize the conception of the lesion than anyone else in this country.

On the whole, this volume, as Volume I, is well illustrated and beautifully bound and printed.

Again we are disappointed with the bibliographies which seem to us inadequate for a work of this size and concept. However, again we recognize the fact that the authors have undertaken a large book and to fill a much needed place in orthopedic literature, and we feel that it is a worthwhile volume for anyone interested in bone and joint surgery.

TOMOGRAPHISCHE DIAGNOSTIK DER TUBERKULÖSEN KAVERNE By KURT GREINER, Assistant am Röntgeninstitut der Klinik. Excerpt from *Zeitschrift für Tuberkulose*, No. 62, 18 pages with 24 illustrations. Published by Johann Ambrosius Barth, Leipzig, 1937. Price RM 3.60.

The value of tomography in the delineation of the roentgen findings in pulmonary tuberculosis is detailed in this reprint. The author reports, in some detail, eleven advanced cases in which the tomographic method permitted the demonstration of tuberculous cavities which could not be clearly seen in the ordinary roentgenogram of the chest. In addition, the size and position of cavities, their differentiation from annular shadows and from localized pockets of pneumothorax, and the clarification of other obscure shadows seen in the ordinary roentgenogram can all be determined much more definitely by this method. In essence, these advantages are gained by the obscuration of all structures lying in front or behind the plane in which the tomogram was made. The author does not give any details as to the exact method he uses, but this has been fully covered in other papers from the Roentgen Institute of Professor Chaoul.

DISEASES OF THE NAILS By V. PARDO-CASTELLO, M.D., formerly Assistant Professor of Dermatology and Syphilology, University of Havana, Cuba. With a Foreword by

ANEURYSM

Cure of a Traumatic Aneurysm by Radium Therapy
L. Valach *Strahlentherapie* 1937 58, 230

A man 25 years of age developed an aneurysm of the left carotid following a stab wound. On admission, the circumference of the neck on the right was 17.5 and on the left 21.5 cm. The author treated him with radium in December 1935, the technic being described in detail. Six months after the last treatment (September, 1936) the patient was free from symptoms, there was a smooth scar in the treated area, and the neck measurements were 17.5 cm (right) and 18 cm (left).

ERNST A. POHLE, M.D., Ph.D.

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The author exposed the hind legs of white rats to roentgen rays in order to study the relation between epilation and skin reaction. Technic: 180 kv, 20 cm F.S.D., 3 mm Al, H.V.L._{0.5} 1.8 mm (?) 85 r per minute. The doses varied from 160 to 3500 r; the animals were observed up to 205 days. Permanent alopecia was obtained after the application of from 1,600 to 2,240 r, which also produced a very marked dermatitis. Fractionating and protraction of the dose did not influence the relation between epilation and dermatitis but only decreased the degree of change as compared with the single dose application. The comparison of three qualities of radiation (180 kv, filtered through 2 mm Cu + 2 mm Al; 180 kv, no filter; and 80 kv, 1 mm Al or no filter) did not reveal any influence of the wave length on the biologic effect provided that the radiation intensities were the same.

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BONES, ANOMALOUS

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Dwight lists 12 anomalies represented by distinct supernumerary bone formations in and about the wrist, any one of which can be mistaken for fracture.

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(2) *Os triangulare or ununited styloid process of the ulna*. The condition occurs often enough to be a matter of importance to industrial surgeons in determining whether the separate fragment found by x-ray examination following an injury to the wrist is a true anomalous bone or an old fracture with non-union or a recent fracture.

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DAVIS H PARDOLL, M D, of Chicago	CHARLES G SUTHERLAND, M B (Tor), of Rochester Minn
ERNST A POHLE, M D, Ph D, of Madison, Wis	

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(6) *The radiale externum* is a separate bone fragment found just distal to the styloid process of the radius. It is not associated with the radius but is an unfused tubercle of the scaphoid (navicular) bone.

(7) *The epilunatum* is the dorsal tip of the semilunar (lunate) bone which occasionally exists as a separate fragment.

(8) *The pretrapezium* is the distal end of the ridge of the trapezium (multangular majus), which may occasionally exist as a separate fragment.

(9) *The subcapitatum* is the distal end of the os magnum (capitate) on the palmar surface, which has been found as a separate fragment.

(10) *The secondary trapezoid* is a free bone found in almost the same position as the pretrapezium but arising from the base of the second metacarpal bone.

(11) *The styloid process of the second metacarpal bone* may develop independently and remain free or become fused with the trapezoid (multangular minus) or os magnum (capitate).

(12) *The os vesalianum manus* is a free bone situated at the base of the fifth metacarpal. The tubercle for the attachment of the extensor carpi ulnaris varies considerably in size and a fragment of it may exist as a separate ossicle.

In the foot and ankle region there are 12 anomalous bones which need to be recognized.

(1) *The os trigonum*. The posterior projecting portion of the astragalus (talus) is grooved for the tendon of the flexor hallucis longus. External to this groove is a prominent tubercle, the posterior process to which the talofibular ligament is attached. This process varies greatly in size and shape. It is often observed developing as a separate epiphysis in the growing individual and various degrees of fusion are found in the adult. In about 10 per cent of cases this process or tubercle is found as a separate or incompletely fused bone.

(2) *The tibiale externum*. Two structures are called by this name. One is a sesamoid in the tendon of the tibialis posterior, the other is the unfused tuberosity of the scaphoid (navicular) bone. Both of these are seen frequently. The sesamoid bone is usually separated sufficiently from the scaphoid so that the question of fracture is not raised. However the ununited epiphyseal tuberosity or true tibiale externum is often quite confusing. Since the tendon of the tibialis posterior muscle is inserted into this tuberosity and is one of the chief muscles of plantar flexion a forcible dorsiflexion might and no doubt often does rupture this attachment and along with the tendon injury may detach a fragment of bone.

(3) *The os peroneum*. A sesamoid bone in the tendon of the peroneus longus where that muscle grooves the cuboid bone. Its position varies considerably some times well forward under the cuboid at other times more posterior beneath the head of the os calcis (calcaneum) or in an intermediate position under the calcaneocuboid articulation. It also varies much in size, shape and density and may be subdivided.

(4) *The os vesalianum pedis*. The unfused tuberosity at the base of the fifth metatarsal bone.

(5) *The secondary os calcis*. The result of calcification in the interosseous cartilage between the anterior process of the os calcis (calcaneum) and the scaphoid and cuboid. This may fuse with the projecting angle of the os calcis proper or with the scaphoid or it may remain as a distinct extra bone.

(6) *The intermetatarsaleum*. This is an extra bone located between the internal cuneiform and the first two metatarsal bones.

(7) *The secondary cuboid*. This may occur as a separate fragment but is usually fused with the scaphoid at the lower and outer edge of that bone.

(8) *The subdivided internal cuneiform*. Of rare occurrence.

(9) *The intercuneiform*. A wedge shaped bone on the dorsum of the foot in front of the scaphoid.

(10) *A divided sesamoid of the great toe*. A fairly frequent anomaly and often misinterpreted as a fracture.

(11) *A separate styloid tip of the tibia*.

(12) *A separate styloid tip of the internal malleolus*.

CHARLES G. SUTHERLAND M.B. (Tor)

CALCULI

Observations on the Formation and the Prevention of Calculi. I. Snapper, W. M. Bendien and A. Polak. *British Jour Urol.* December 1936 8, 337-345.

The authors came to the following conclusion: urine is a supersaturated solution of many substances. Large quantities of different substances, practically insoluble are present in solution in it. This may partly be explained by the simultaneous presence of other so-called hydrotropic substances which further the solubility of the insoluble salts. The hydrotropic action of urea, hippuric, salicylic and mandelic acid is discussed. Besides this hydrotropic action of the substances just mentioned the presence of different colloids may also collaborate to the solution of the insoluble salts. Chondroitic sulphuric acid and nucleic acid may help specially to keep the insoluble salts in solution.

However for the calculogenesis the precipitation of colloids is more important than the precipitation of salts. In the formation and the growth of kidney stones flocculation of colloids is the primary process—which is followed only by secondary incrustation with salts. Therefore it must be possible to prevent calculogenesis by preventing precipitation of colloids. Different organic salts can be used for stabilizing solutions of colloids. Experiments show that the hippuric acid of the urine must belong to these colloid stabilizing substances.

Thus the hippuric acid of the urine might prevent formation of stone nuclei by stabilization of the colloids or secondary incrustation by its hydrotropic action. Administration of sodium benzoate by mouth did prevent stone formation in rats on CaCO_3 rich diet. It also stopped phosphaturia in men and diminished renal colic in patients. The authors also state that other more powerful stabilizers of the colloids of the

urine (salicylates, mandelates) might be used for this purpose

DAVIS H. PARDOLL, M D

well varied and balanced diet is the best Climatic conditions also may be of importance

ERNST A. POHLE, M D, Ph D

CANCER (DIAGNOSIS)

Investigations of Blood-serum Lipoids in Cancer and Other Cases, Mean Molecular Weight of Free and Combined Acids in Blood serum Lipoids of Cancer and Other Subjects, Ultra-violet Absorption Measurements H H Barber and L A Woodward *Biochem Jour*, August, 1936, 30, 1463-1471 (Reprinted by permission from *British Med Jour*, Dec 19, 1936, p 104 of *Epitome of Current Medical Literature*)

Barber reports having investigated von Noë's method (*Strahlentherapie*, 1931, 42, 616) of diagnosing cancer from the chemical analysis of blood serum lipoid L A Woodward in Part II of the same paper reports having tested the claim that cancer can be diagnosed from the shape of the ultra violet absorption curve given by the blood-serum lipoids The chemical analysis consists in the determination of the fatty acid and saponification values of the lipoid from which values the 'Krebzahl' is calculated According to von Noë, Krebzahl values of over 130 are indicative of cancer Barber found that the Krebzahl values of 19 specimens of blood from advanced cancer cases had a mean of 205 and a range of 107 to 300, while the values for 22 specimens from non-cancer cases had a mean of 199 and a range of 86 to 304 There is no indication from these figures that a high Krebzahl is characteristic of cancer and Barber suggests that the detection and estimation of the acids of low molecular weight generally considered to be characteristic of the abnormal glycolysis of malignant tumors are not quantitative by the methods employed to determine the Krebzahl

Woodward using a double quartz monochromator and photo-electric spectrophotometer measured at ten different wave lengths the extinction coefficients of the alcohol ether solutions of the serum lipoids from nine of the cancer cases and 11 of the non-cancer cases investigated by Barber As only the relative shapes of the absorption curves were to be compared corrections for variations in the molecular concentrations of the lipoids were unnecessary He was unable to find any characteristic differences in the curves such as might serve as a diagnostic test for cancer Both methods of testing the serum lipoids seem therefore to be useless for the diagnosis of cancer

CANCER (THERAPY)

Supplementary Treatment of Cancer Patients H Auler *Strahlentherapie* 1937, 58, 204

The author discusses in a very general way some of the measures which may be considered as adjuncts to irradiation in the treatment of cancer He mentions medication, chemotherapy, vaccines sera hormones catalysts, and also diet In regard to the latter he does not advocate the so-called raw food diet but believes that a

THE COLON

Diffuse Adenomatosis of the Colon Fred W Rankin and Allen E Grimes *Jour Am Med Assn* Feb 27 1937 108, 711-715

Diffuse adenomatosis of the colon as a distinct clinical entity has been recognized for many years but the histopathology revealing its malignant tendency has been a more recent contribution which has done much to alter modern views with regard to treatment

The tumors are usually multiple and widely distributed often extending from the anus to the cecum but have a tendency to appear approximately eight times more frequently in the rectosigmoid and rectum than in any other section of the colon This is particularly significant in the light of the similar occurrence and ratio of distribution of carcinoma of the colon It suggests a relationship and studies of large segments or the complete colon exhibiting this form of pathologic involvement have supported this suspicion

A familial tendency or hereditary factor has been repeatedly sustained by various investigators and conforms with their experience

The terms "polyposis," "polypoidosis," and "diffuse adenomatosis" have been frequently used to designate the adenomatous hyperplasia "Polyposis" may mean only one or several polyps while "polypoidosis" indicates that the entire inner surface of the large bowel, from the anus to the cecum, contains polyp-like elevations

The cause of true adenomatosis has not been determined The origin of the acquired or post-inflammatory polyps is quite different and better understood Although the etiology of post inflammatory and true polyps is accepted as being different, one must not forget that the former as well as the true polyps may undergo malignant change

A pathologic study of true polyps of the colon emphasized the potential malignancy of this condition and greatly influenced the method of treatment On histologic examination the tumors fell readily into three major divisions (1) Roughly nodular and invariably pedunculated with no features to indicate that they were any more liable to malignant development than the normal intestinal mucous membrane, (2) polyps showing structural changes in both the epithelial and the connective tissue elements—this group is often the source of malignancy (3) polyps of this group ordinarily do not exceed the size of a split pea the nodules approach cancerous changes before the tumor has become large enough to be played on by the forces of peristaltic action, which is thought to be influential in elongating the tumors

There is usually little difficulty in establishing the diagnosis if the condition is kept in mind and the patient is subjected to a thorough gastro intestinal

investigation including roentgenologic examination of the barium filled colon

CHARLES G SUTHERLAND, M B (Tor)

CONTRAST MEDIA

Epidural Lipiodol in Sciatica G Carriere and A Verhaeghe *Écho Méd du Nord*, July 26, 1936 6, 186-197 (Reprinted by permission from *British Med Jour* Oct, 10, 1936, p 58 of *Epitome of Current Medical Literature*)

According to the authors this treatment, introduced in 1924, has recently been reported to have induced speedy improvement in 70 per cent of a series of 1,500 cases of sciatica. The lipiodol is injected into the connective tissue below the dural sac through the posterior inferior ohturating membranc, this has the shape and position of a triangle of which the upper angle is formed by the last (that is, the fourth or third) sacral spinous process and the lower two angles by the two posterior internal sacral tubercles. Injected in sufficient amount (20 c c is stated to be essential) the lipiodol passes up extradurally as high as the second lumbar vertebra and sends prolongations along the nerve roots, these are bathed in lipiodol in the case of the sacral plexus for 10 cm. Injection otherwise very painful should be preceded by local anesthesia of the skin (2 c c of 2 per cent scurocaine) and injection of the track by 20 c c of 0.5 per cent solution. A wait of fifteen minutes now precedes the slow injection of lipiodol, which like the anesthetic solution is given through a screw syringe such as that of Lafay with a needle not longer than 5 cm. (Longer needles may cause an involuntary lumbar puncture.) To reach the epidural space the syringe after being introduced perpendicularly to the ohturating membrane is tilted downward at 60 degrees at the butt and now penetrates the canal upward and parallel with its long axis. Of the three bony points to be recognized the lower two are usually easily felt and a puncture 5 to 7 mm above the line joining them will be successful if the upper one only is palpable the needle should be put in directly below it. The lumbar puncture needle is unsuitable being too long too frail and too fine. The insertion may be assisted by radiographic control.

GYNECOLOGY AND OBSTETRICS

The Influence of Irradiation of the Thyroid on the Ovary E Momighano *Strahlentherapie* 1937 58, 53

In order to study the relation between thyroid and ovary the author exposed the thyroid gland of adult rabbits to roentgen rays. The anterior cervical area was irradiated with from 375 to 2,250 r the average dose varied between 750 and 1,500 r (184 kv 0.7 mm Zn 23 cm FSD 5 x 7 cm sq field). Four animals were exposed at intervals of one month four untreated rabbits being kept as controls. The histologic changes seen in the thyroid are described in detail and illus-

trated by photomicrograms. They varied according to the dose and the time interval between exposure and histologic study. Following 375 r there was only slight hyperemia of the thyroid while with higher doses cystic degeneration with destruction of the follicle epithelium and hyperplasia of the interstitial tissue occurred. The peak of the reaction was seen four months after the exposure. The ovaries in the same animals were also studied histologically and the observed changes are described and illustrated by photomicrograms. It was interesting to note that rabbits showing marked changes in the thyroid showed also definite histologic changes in the ovaries. As a matter of fact animals that received 2,250 r over the thyroid showed marked atrophy of the ovaries four months after the thyroid exposure. In other words irradiation of the thyroid led to a true sterilization. The author emphasizes that in contrast to statements made in the literature as to the relatively high radioresistance of the thyroid he found the gland definitely radiosensitive and refers to his histologic observations.

ERNST A POHLE M D, Ph D

HEMORRHAGE

Classification and Treatment of the Hemorrhagic States Stacy R Mettler and Katherine Purviance *Jour Am Med Assn* Jan 9 1937 108, 83-86

The difficulties inherent in the problem of bleeding and blood clotting offer limitations in constructing an entirely satisfactory classification of the hemorrhagic states. A classification from a clinical point of view may be made depending on the defect in the clotting mechanism or the vascular tree.

In addition to a carefully taken history of the course of the illness and a thorough physical examination laboratory aid is necessary for the diagnosis of hemorrhagic diseases. Since specific nutritional elements are needed to maintain the integrity of capillaries and to form liver and blood proteins a detailed history of the dietary habits of the patient should be recorded.

On the basis of the information gained with regard to a familial hemorrhagic tendency the physical signs and the abnormalities of the blood the hemorrhagic diseases may be classified within limitations.

In a survey of the therapeutic measures repeated roentgen irradiation over the spleen in suitable dosage is given as an excellent means of increasing the number of circulating blood platelets in patients with idiopathic thrombocytopenic purpura hemorrhagica.

CHARLES G SUTHERLAND M B (Tor)

THE PROSTATE

Early Diagnosis and Radical Treatment of Carcinoma of the Prostate Edward L Keyes and Russell S Ferguson. *British Jour Urol* December 1936 8, 346-352

The authors are of the opinion that carcinoma of the prostate should be attacked as a curable disease. No

large proportion of cases will be controlled unless diagnosed by (aspiration) biopsy, before diagnosis is possible by rectal touch even with a sound in the urethra

They propose an operation which with low operative mortality promises to compare favorably with the total prostatectomy of Young. Grave post-operative radium burns are preventable by proper technic, and such prevention is especially easy to assure in the early curable cases

DAVIS H. PARDOLL, M.D.

The Conservative Treatment of Carcinoma of the Prostate. Cyril A. R. Nitch. *British Jour. Urol.*, December 1936, 8, 329-336

The conservative treatment given by the author comprises radiotherapy, surgery and surgery with radiotherapy.

The immediate results of x-ray treatment are often excellent but the ultimate results are disappointing. In some cases x-rays cause rapid increase of the growth and dissemination. The best results are obtained by the five field maximum method (Holfelder-Reisner) giving a total depth dose of from 150 to 200 per cent on the prostate. The intensive split-dose method of Levitt now under trial seems productive of better results. At present only 6 per cent of the cures can be claimed for modern methods of x-ray therapy.

The effects of radium are better especially when applied in large doses to the rectal vesical and urethral surfaces of the prostate. Before treatment is commenced a thorough clinical, biochemical and radiological examination must be made and a portion of the prostate should be removed by electro-resection for microscopical examination. When renal function tests are below normal preliminary drainage of the bladder is necessary. About 70 mg. of radium are used thus: 14 mg. to the postero-lateral surfaces, 50 mg. to the vesical surface and 5 mg. to the urethral surface. Though only a few cases have been treated in this way the cure rate up to the present has been 28 per cent. The method is therefore worth an extended trial.

Conservative surgery consists of suprapubic drainage, transplantation of the ureters and electro-resection. Transplantation of the ureters into the large intestine is preferable to suprapubic drainage but can be performed only in carefully selected cases. Electro-resection is the best palliative measure for the relief of obstruction by growth at the neck of the bladder; it is of no value when the obstruction is due to invasion of the prostatic urethra. It is probable that in the future electro-resection followed by some form of radiotherapy will be the method of choice.

DAVIS H. PARDOLL, M.D.

THE SKIN

Arthropathica Psoriatica. Harold Jeghers and Leon J. Robinson. *Jour. Am. Med. Assn.* March 20, 1937, 108, 949-952.

Arthropathica psoriatica (psoriasis arthropathica) as a distinct clinical entity has been of particular interest since Alibert in 1822 recognized the occurrence of joint pains in psoriasis. Bazin in 1860 distinguished between psoriasis with arthritis and without arthritis and applied the term 'psoriasis arthritica' to the former variety. Adrian reviewed the subject in 1903 and did much to establish this syndrome as a clinical entity.

Since cases are so rarely reported the syndrome is probably an unfamiliar one. O'Leary saw eight instances of this syndrome among 1,400 cases of psoriasis.

In reported cases the dermatologists tend to ignore the arthritis while the internists pay little attention to the skin lesions.

The diagnosis of true arthropathica psoriatica depends mainly on the close relationship which the exacerbation and subsidence of the skin and joint manifestations bear to each other.

Joint manifestations commonly appear a short interval (from days to weeks) following a change in the form of the psoriasis. The skin lesions become erythematous atypically distributed, increased in extent and/or pustular. The arthritis is usually polyarticular and involves both small and large joints. Severe symmetrical involvement of the terminal joints of the fingers and toes has been commented on as common and characteristic. This may occur whether or not the other joints of the fingers and toes are involved. There is also a striking parallelism between the severity of the skin and joint manifestations.

Psoriatic arthritis lasts from weeks to months but may in rare cases persist permanently. The skin lesions usually subside either spontaneously or after appropriate therapy followed in a few weeks by recession of the arthritic symptoms.

The syndrome may be repeated several times at yearly or longer intervals. A characteristic feature in most cases is the marked return of joint function after the first or first few attacks. However, permanent joint damage may follow repeated or long standing attacks of this syndrome.

The joint lesions are not characteristic and may resemble either rheumatoid arthritis or osteoarthritis. The changes vary from slight periarticular swelling to actual destructive lesions. Intermittent hydroarthrosis may occur. A typical joint is swollen, tender and warm to touch and with painful and limited mobility. Ankylosis is rare at the start but may occur later.

The roentgen picture varies and is not characteristic. Narrowing of the joint space, periarticular swelling and slight bone atrophy are common in the early phase. After repeated or long standing attacks, hazy outline of the bone, roughening of the articular surface, destructive changes and occasionally hypertrophic reactions which cause ankylosis may appear.

The parallelism between the severity of the skin and joint lesions seems to support the theory that the arthritis is due to toxic products absorbed from the skin lesions.

CHARLES G. SUTHERLAND, M.B. (Tor.)

THE SKULL

The Roentgenologic Appearance of the Skull in Cases of So-called Genuine Epilepsy E Fischel *Archivio di Radiologia*, March-April, 1936, 114-120

This is a preliminary report of a study Fischel made of the skulls of 21 cases of so called genuine epilepsy. Many of the skulls showed some though perhaps slight, abnormality. He feels that the term "genuine epilepsy" should be limited to those rare instances in which there is no roentgenologic, developmental or circulatory lesion which might cause the disease.

E T LEDDY, M D

THE SPINE

Osteomalacia of the Spinal Column E Meulengracht and A Rothe Meyer *Ugeskrift for Læger* Oct 8, 1936 98, 961-986 (Reprinted by permission from *British Med Jour*, Dec 19 1936, p 101 of *Epitome of Current Medical Literature*)

The authors trace the changes in the conceptions of the pathology of osteomalacia since Trousseau, in 1868 maintained that it was identical with rickets and curable with cod liver oil. At the beginning of this century osteomalacia was regarded as a disease of the endocrine glands. Now the swing of the pendulum has taken osteomalacia out of the sphere of the endocrine glands and identified it as a deficiency disease closely related to rickets and traceable to disturbances of calcium and phosphorus metabolism due to lack of vitamin D.

The authors give an account of four cases of osteomalacia of the spine observed in the course of the past three years, the ages of the patients being respectively 58, 42, 64 and 77. The disease developed in the first case in the course of from four to six years during which the patient was subject to constant pain in the shoulders, back and loins. Rapid and striking improvement which has now been maintained for over two years was effected under treatment with vitamin D and calcium. In the second case a man had for five years systema-

tically lived on an inadequate diet on account of his dyspepsia. He developed pain in the back, and the x rays showed extensive destruction and collapse of the dorsal and lumbar vertebræ. On a liberal mixed dietary including vitamin D and calcium, the pain ceased, the progress of the bony disease was arrested, and the improvement thus achieved was maintained. After giving details of the other two cases the authors point out that common to all was a defective dietary over a long period and hour glass deformity and collapse of certain vertebræ and a remarkably rapid and durable recovery in response to the exhibition of vitamin D and calcium. The authors also give an account of a fifth patient, a man of 69, who lived by himself and who developed not only scurvy due to his defective diet but also radiologically demonstrable deformity of the lumbar vertebræ.

TUMORS (DIAGNOSIS)

Tumors of the Mediastinum Arising from the Reticulo-endothelial System Roentgenologically Considered W G Herrman *Jour Med Soc New Jersey*, December, 1936, 33, 693-695

Because of the inaccessibility of mediastinal tumors and the rarity of mediastinal biopsies the roentgenologist carries a great responsibility in such conditions. Careful fluoroscopy is the first procedure with an intensive study in various positions. Radiographs should then be taken in positions determined by fluoroscopy as being most helpful including postero-anterior, lateral, and oblique views. The use of iodized oil, artificial pneumothorax and barium may help in localization as well. Substernal thyroid enlarged thymus, benign tumors such as dermoids and neuroomas must be differentiated. Aneurysms often prove very difficult to differentiate. Metastatic malignant tumors, lymphosarcomas and Hodgkin's disease are other considerations. Sensitiveness of tumors to radiation therapy may help in diagnosis.

W A SODEMAN, M D

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GROSS ANATOMIC CHANGES IN THE LUNGS¹

By PHILIP HILLKOWITZ, M D , *Denver, Colo*

IN interpreting an x-ray plate the roentgenologist conceives in his mind's eye a picture of the actual condition of the organ or tissues, as translated from the shadow into a visual image on the retina. He is, or should be, therefore, familiar with the pathologic alterations underlying the structures under observation which necessarily implies some knowledge of the various morbid processes and their effects on the several organ systems and separate organs. We must bear with the pathologist in his pardonable assumption that pathologic anatomy and histology are the groundwork for scientific diagnosis and treatment of disease and should constitute an important part of the training of the internist, the surgeon, and particularly the roentgenologist. Yet, even the specialist in pathology is not often in a position to get a close view of diseased organs or tissues as they actually are in the living pulsating individual. When seen in the morgue at the autopsy table, or in the laboratory after operative removal, the picture is not quite like that seen by the surgeon *in vivo* when the circulation in the parts is still intact, and the colors and nuances of the structure are still alive. Much less true to reality is the appearance after immersion in preservatives and fixatives. Immeasurably

distorted are the tissue cells when viewed under the microscope after undergoing the processes of fixation and differential staining with dyes. While we make our fine diagnosis by these valuable methods, the structures are not seen in their actual reality. However, like the archeologist or the geologist, we reconstruct from the altered material remains a good working image of what the organ or tissue would be like if observed under ideal conditions.

The task is far more difficult for the roentgenologist who has to base his interpretation on lights and shadows, yet, armed by his fundamental knowledge of the underlying lesion and the results of research of investigators in this field, he brings his talent to the service of the colleagues who consult him. His fund of experience will be greatly heightened when he personally follows his diagnoses through the surgery into the laboratory, and in the inevitably fatal cases to the morgue. The visual impressions thus gained are much more valuable than text-book illustrations, serviceable as those are, and will amply repay the time spent and greatly enhance his usefulness.

In the following sketches of the gross anatomy of the principal lesions of the lung, I shall endeavor to present only the high lights of the naked eye appearance with the hope that it will stimulate more detailed study in the special books and monographs on this comprehensive subject.

¹ Presented before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati Nov 30-Dec 4 1936

PNEUMONIA

In but few organs of the body is the contrast between the normal and the diseased so striking as in lobar pneumonia. Within a couple of days, the gray colored crepitant air-filled organ is converted into a red or reddish-gray solid and friable substance, to which has been given the classical term hepatization because of its resemblance to liver tissue. The consolidation is due to the outpouring of an exudate in the alveoli, displacing the air content, and filling the lumen with a fibrinous liquid which soon gels, giving the organ a solid consistence. On cutting into it, one finds a dry surface, with the fibrin plugs protruding from the bronchioles which lend the transected parts a granular appearance. The organ does not collapse when the thorax is opened and sinks when placed in water. It should be distinctly emphasized that despite its name the process does not necessarily involve the whole of the lobe or lobes but may affect only a portion. The extent of the involvement is due to several factors which for lack of space can only be mentioned here—the age of the individual, his resistance, and the virulence of the invading organism. The classification of pneumonia in its several stages of engorgement, red hepatization, gray hepatization, and resolution, so dear to the heart of the older writers of text-books, are not given their former prominence. We know now that some of these may be found at the same time in different portions of the lung due to the fact that the process is one of continuity, progressing from the hilus to the pleural surface.

In red hepatization the exudate in the alveoli contains many red blood cells which have escaped from the capillaries in the walls and give the organ the characteristic red or reddish-gray color. In the next stage, that of gray hepatization, the erythrocytes have disappeared, the capillaries in the septa are compressed by the exudate, and the color of the organ is distinct gray or grayish-yellow. In the stage

of resolution there is a rapid liquefaction and absorption or discharge of the alveolar contents and correspondingly a return of the air into the sacs.

The distinction between lobar and lobular pneumonia is nowadays not given the prominence it once held. The pathologic process is practically the same, the extent of involvements as above mentioned varying with the virulence of the causative micro-organism and the age of the individual. The lobular or bronchopneumonia type is seen particularly in the young and the aged.

In rare cases, instead of resolution and a resorption of the exudate in the alveoli, there may be organization—the production of fibrous tissue which fills the air sacs and shuts out the air. The process is known as a carnification of the lung.

In this connection, it may be well to describe lung abscess which may arise as a complication of pneumonia but more frequently of bronchogenic origin, due to the extension of a putrid bronchitis, the aspiration of a foreign substance, rupture of a cancer of the esophagus, etc. Here we have a destruction of the lung parenchyma, with formation of a creamy pus which may or may not be of foul odor, depending on the kind of infecting organisms.

It is interesting to note that lung abscess is seen three times more often in the right lung than in the left due to the more vertical course of the right bronchus. The abscess wall is ragged and tears easily. Sometimes in older cavities, it consists of a fibrous capsule.

In the similar lesion of gangrene of the lung, putrefactive processes are evident. The greenish or brownish softened tissue and dirty fluid emit an offensive odor. Large areas may be thus affected.

EMBOLISM AND INFARCTION OF THE LUNG

These unfortunate complications occurring after operative procedures, especially on the pelvic organs, and in chronic valvular disease of the heart, lead to an obstruction of the circulation in the affected part with the formation of a dark red

triangular area having its base on the pleural surface and the apex at the point of obstruction. The size of the necrosed area varies with the size of the nutrient vessel. In sudden death a large embolus may be found at the bifurcation of the pulmonary artery on one of the main branches. In the smaller vessels it may produce definite symptoms and certain characteristic shadows in the roentgenogram.

BRONCHIECTASIS

With the introduction of lipiodol into roentgenologic technic the diagnosis of this condition has been greatly facilitated. The bronchus may show a diffuse cylindrical or sac-like widening. The walls may be thinned out, producing hernial protrusions with accompanying atrophy or disappearance of the mucous membrane. On the other hand, there may be a thickening of the walls with hypertrophy of the mucosa and formation of polypoid elevations which may be mistaken for tumors. Some dilated bronchi may show alternating grooves and projections on the inner surfaces. The bronchiectases may ulcerate and form large cavities, particularly in tuberculosis.

ATELECTASIS

Of great interest to the roentgenologist is this condition in which the alveoli become airless. Leaving out of consideration the congenital type, we may consider the atelectasis due to compression as seen in empyema, pneumothorax, or serous effusion or pressure of a tumor, or enlargement of the heart. Another and frequent cause is obstruction of a bronchus by mucus or a foreign body. An extreme example of atelectasis is acute massive collapse of the lung. In all these cases the portion involved is airless, firm and retracted, and of a bluish or grayish color.

EMPHYSEMA

The opposite of the previous condition, emphysema, is manifested by an increased distention of the alveoli. The lungs are

voluminous and cover the pericardial sac completely. Blebs project from the surface, and the margins are rounded. The lung pits on pressure and has a characteristic pillowy feel.

TUBERCULOSIS OF THE LUNG

The picture in this disease is one of great complexity. It differs greatly in accordance with the dose, *ie*, the number of bacilli invading the tissue and the resistance of the patient. It also varies as to whether the infection is primary or secondary. The former occurs in children who for the first time are attacked by the tubercle bacillus, and who, therefore, have not had the benefits of the immunizing process of previous minor invasions. Time does not permit a detailed exposition of the pathogenesis in tuberculosis, which is so essential to an understanding of the gross and microscopic lesions of this important malady. William Snow Miller's conception of the acinus as the unit of the lung which is discussed in this symposium also throws light on the pathology and is likewise illuminating in tuberculosis of the lung.

In the primary tuberculosis of childhood there are one or more caseous areas of greater or lesser extent—in effect, patches of tuberculous bronchopneumonia, also miliary nodules in the vicinity. Characteristic of the primary origin is the presence of chains of minute nodules along the lymphatics leading to the regional lymph nodes which are markedly enlarged and caseous.

In secondary tuberculous infection of the lung, by far the most frequent, we have a great variety of gross lesions which it is difficult to classify satisfactorily. According to Boyd, we may, as a matter of convenience, divide the cases into the fibrocaseous type, caseous pneumonia, and acute miliary tuberculosis. In fibrocaseous or ulcerative tuberculosis of the lung we may see one or several cavities, usually situated near the apex. They have rather smooth, thickened fibrous walls, occasionally an intact bronchus or

blood vessel may wend its way across the cavity. In the adjoining tissue and more or less distant areas are opaque solid lesions of gray color and of varying size, down to minute miliary lesions in the lower portion. There are, of course, infinite gradations of this gross pathologic picture, depending on the play of contending forces, of the size of the dose of tubercle bacilli *versus* the resistance of the individual. Here the roentgenologist has been of immense assistance to the clinician in interpreting the shadows on his plate in terms of pathologic anatomy. The acinar unit, as it is invaded by the tubercle bacillus with the involvement of the respiratory bronchiole by granulation tissue, the exudate, pouring into the alveolus or its collapse by inflammation of the septa, constitute a key to the explanation of the gross appearance as seen in reality or on the shadow. The white strands on the cut surface, the thickening of the bronchi, of the blood vessels and of the pleura are indications of fibrosis, the conservative productive process.

In tuberculous caseous pneumonia, we see a large portion or all of a lobe or even of the entire lung converted into a solid mass, not unlike the appearance of gray hepatization in pneumonia. It may also be mistaken for a primary carcinoma of the lung. The lymph nodes are likewise apt to be involved in the caseous process.

In the acute miliary type, the lungs are studded with miliary tubercles more or less translucent, the later lesions being opaque and caseous.

Syphilis need only be mentioned by name as its occurrence is rare and difficult of differentiation from tuberculosis. Hodgkin's disease, also quite rare, is alluded to because of a case seen in consultation with Dr. Wasson, in which cavities were present and the diagnosis was made only by microscopic examination.

TUMORS OF THE LUNG

In the last decade or two primary carcinoma of the lung has assumed a marked

importance. Formerly considered a rarity, it now ranks second only to carcinoma of the stomach. Whether the greater incidence is due to better methods of diagnosis or to an actual increase is beside the point. The roentgenologist should always keep the possibility in mind. Benign neoplasms are rare in comparison with the malignant, usually carcinoma. Growths resembling round-cell sarcoma, and so diagnosed, have been found on closer investigation to be of epithelial origin.

The great majority of primary carcinomas of the lung (90 per cent) constitute the so-called hilus type which originates in the bronchus from whence it spreads through the bronchial tree into the surrounding lung substance, producing a gray mass often enlarged in size by the involvement of the neighboring lymph nodes. The growth is usually firm but occasionally undergoes necrosis and may be the seat of abscess or cavity formation. By pressure on a bronchus it may cause atelectasis of a portion of the lung or a bronchiectasis.

In a small proportion the tumors are of minute size, just palpable to the finger and resembling miliary tuberculosis. There is still a rare diffuse form of primary carcinoma of the lung involving a whole lobe, which may be mistaken for a pneumonia.

DISCUSSION

DR. PHILIP HILLKOWITZ (closing). I have little to add except to say that we were greatly stimulated by Dr. Dunham's challenge to the pathologists and physiologists to clear up a great many points that we do not know.


It has always been a great pleasure to have our colleagues in the roentgenological field come to the pathologists and stimulate us by these perplexing questions. It is always productive of progress.

CRANIAL DYSPLASIAS OF PITUITARY ORIGIN¹

By HECTOR MORTIMER, GEORGE LEVENE, and ALLAN WINTER ROWE*

From the Department of Biochemistry, McGill University, Montreal, Canada, and the Evans Memorial for Clinical Research and Neuro-endocrine Research, Boston

PART I

 OUR interest in the proportions and architectural structure of the human skull, as seen in cranial skiagrams, dates from the observation by the senior author, in 1932, of changes suggestive of such as are known to occur in acromegaly, in a male of 26 years—the subject of catatonic dementia præcox.

When first seen, this patient had been about a year in Worcester State Hospital and had been studied for over seven months by the research service (1). In view of this finding, certain facts in the patient's history were of special interest.

Described as normal at birth, he walked at one year, but at the age of three he showed a "weakness of the legs" and was unable to walk for several months. At eight or nine he suffered from leg pains, described at the time as "growing pains." There was a history of trauma to the face by a baseball bat at the age of twelve, to which was subsequently attributed the frequent frontal headaches of which he later complained, as well as the nasal septum deviation for which he underwent an operation when 18 years old.

When about fourteen or fifteen years old he grew rapidly so that, from being a boy of average size in public school, he found himself, when he entered high school, to be one of the tallest boys, not only in his class, but in the school.

In public school his scholastic record had been good, but in high school he failed markedly in performance and, since he was ambitious, this was one of the earliest

causes of his self-dissatisfaction. While in high school he suffered greatly from fatigue and frequently complained of headache, vertigo, and occasionally of diplopia.

When examined at the age of 26, in 1932, he showed no evidence of any organic disease, but the data derived from the first month's intensive physiological study showed deviations from normal limits highly suggestive of disturbed pituitary function (2). The second month's study, carried out after an interval of two months, gave the data which, while not within normal limits, did not point so strongly to pituitary implication, and a final month's study, done after a further intermission of two months, gave data which materially were within low normal limits.

The patient's psychiatric state during these three periods also showed variation. During the first he was in well marked catatonia, during the second he was "reacting" and excitement was dominant, while during the third he "recovered" to the extent that he could usefully be employed in clerical work in the hospital office.

Assuming for the purpose of further investigation that the changes in physiologic function levels were not primarily of psychogenic origin, but might be related to disturbance of pituitary function, it became a matter of great clinical interest to see whether he bore any stigmata of past growth disturbance, either of under- or over-active nature.

His height was 181.6 cm, trunk height 95.7 cm, so that his sitting height index was 0.526, his span was 67 mm greater than his height—proportions which are by no means abnormal, despite the burst of growth reported in the history. When

¹ A preliminary report on this material was made at the annual meeting of the Association for the Study of Internal Secretions at Milwaukee June 12, 1933.

* Deceased Dec 6, 1934.

blood vessel may wend its way across the cavity. In the adjoining tissue and more or less distant areas are opaque solid lesions of gray color and of varying size, down to minute miliary lesions in the lower portion. There are, of course, infinite gradations of this gross pathologic picture, depending on the play of contending forces, of the size of the dose of tubercle bacilli *versus* the resistance of the individual. Here the roentgenologist has been of immense assistance to the clinician in interpreting the shadows on his plate in terms of pathologic anatomy. The acinar unit, as it is invaded by the tubercle bacillus with the involvement of the respiratory bronchiole by granulation tissue, the exudate, pouring into the alveolus or its collapse by inflammation of the septa, constitute a key to the explanation of the gross appearance as seen in reality or on the shadow. The white strands on the cut surface, the thickening of the bronchi, of the blood vessels and of the pleura are indications of fibrosis, the conservative productive process.

In tuberculous caseous pneumonia, we see a large portion or all of a lobe or even of the entire lung converted into a solid mass, not unlike the appearance of gray hepatization in pneumonia. It may also be mistaken for a primary carcinoma of the lung. The lymph nodes are likewise apt to be involved in the caseous process.

In the acute miliary type, the lungs are studded with miliary tubercles more or less translucent, the later lesions being opaque and caseous.

Syphilis need only be mentioned by name as its occurrence is rare and difficult of differentiation from tuberculosis. Hodgkin's disease, also quite rare, is alluded to because of a case seen in consultation with Dr. Wasson, in which cavities were present and the diagnosis was made only by microscopic examination.

TUMORS OF THE LUNG

In the last decade or two primary carcinoma of the lung has assumed a marked

importance. Formerly considered a rarity, it now ranks second only to carcinoma of the stomach. Whether the greater incidence is due to better methods of diagnosis or to an actual increase is beside the point. The roentgenologist should always keep the possibility in mind. Benign neoplasms are rare in comparison with the malignant, usually carcinoma. Growths resembling round-cell sarcoma, and so diagnosed, have been found on closer investigation to be of epithelial origin.

The great majority of primary carcinomas of the lung (90 per cent) constitute the so-called hilus type which originates in the bronchus from whence it spreads through the bronchial tree into the surrounding lung substance, producing a gray mass often enlarged in size by the involvement of the neighboring lymph nodes. The growth is usually firm but occasionally undergoes necrosis and may be the seat of abscess or cavity formation. By pressure on a bronchus it may cause atelectasis of a portion of the lung or a bronchiectasis.

In a small proportion the tumors are of minute size, just palpable to the finger and resembling miliary tuberculosis. There is still a rare diffuse form of primary carcinoma of the lung involving a whole lobe, which may be mistaken for a pneumonia.

DISCUSSION

DR. PHILIP HILLKOWITZ (closing). I have little to add except to say that we were greatly stimulated by Dr. Dunham's challenge to the pathologists and physiologists to clear up a great many points that we do not know.

It has always been a great pleasure to have our colleagues in the roentgenological field come to the pathologists and stimulate us by these perplexing questions. It is always productive of progress.

as well as that of most recent acquisition in phylogeny, is "mund." It is obvious that for the purpose of investigation a standpoint had been assumed which favored the physiogenic rather than the psychogenic etiology of mental disease.

The first step in the utilization of this lead was a scrutiny of the cranial skiagrams of all patients previously studied by the research service. At that time between 60 and 70 males, between the ages of 20 and 40 years, had been fully investigated under Hoskins' "seven-month plan" (3). All had had cranial skiagrams taken and these were examined by the senior author with Dr Hoskins and Dr Sleeper, the identity of the patients not being known. Of this number, 11 were found to show definite hyperostosis and hyperpneumatization, allowing them to be grouped with the original case. The significance of the changes seen in these crania became evident when they were compared with the skiagram of a female patient, not studied in the research service, an acromegalic twice operated upon by Dr Cushing for eosinophilic adenoma of the pituitary, who since had become demented. At the time of the second operation the hospital case-notes contained a statement that the thickness of the skull at the vertex was 15 mm. The 11 cases found showed changes similar in type, though less in degree, to the changes evident in this known acromegalic, with the exception that none of the 11 showed any abnormality of the sella turcica.

Since these skiagrams had been taken to ascertain the condition of the sella, it became evident that there had been a tendency to report on the condition of this structure, omitting to observe the general cranial change, or to have accounted for it, if seen, by the fact that there is considerable normal variation in human crania. It was evident that, clinically at least, there was a tendency to focus disproportionate attention on variations of size and shape of the sella, as indices of pituitary function. In other words, observers tended to fail to see the "forest" of evidence of

general and differential cranial change for the "trees" of the sella turcica. We had subsequently cause to regret this fact, when it was found, in certain cases of special interest studied in the past, that only a circumscribed sellar skiagram had been taken, from which little information could be derived beyond the fact that the pituitary fossa was normal in size and had not undergone structural change.

Naturally it was recognized that there is considerable variation in developmental proportion and architectural structure in human crania and that there may be many influences responsible for this. Apart from the effects of disease, congenital or acquired, local or general, it is usually admitted that race and family, sex and age, nurture and nourishment are important factors, whatever may be the mechanisms by which they act.

It did appear reasonable, however, that a radiologist, routinely inspecting a large number of cranial skiagrams from any given population, even though composed of mixed racial elements, would in the course of the observation become impressed, consciously or unconsciously, with the degree of average variation, beyond which at either extreme he would have little difficulty in recognizing degrees of abnormality, although he might be unable to suggest a causal mechanism. Also such observations would not be of lessened value just because the zone of average cranial growth, in the population, had not been delimited by recorded measurements derived from roentgenologic studies.

This point of view was discussed with several roentgenologists of wide experience who found themselves in agreement with it. The skiagrams of the 11 cases from Worcester State Hospital were next examined by one of us (G. L.), who compared them with skiagrams of acromegalics, previously studied in that institution, and his opinion was that none of the crania was normal. All showed changes similar to those seen in the diagnosed acromegalics: one to a "slight" degree, four "moderate" in degree, and



Fig 1 Patient, F G, aged 28 years, male
No 4,254, Worcester State Hospital Diagnosis
Catatonic dementia præcox

viewing this patient naked, however, one was struck by the fact that, while the extremities were heavy in both bone and musculature, the thorax was poorly developed and poorly clad. There was well marked dorsal kyphosis, the chin was prominent and held high, the forehead seemed receding with prominent supra-orbital ridges, and the body was held in a slouch with flexion of the knees, slight genu valgum, and eversion of the feet, which were slightly flat—the whole presented a picture not unlike the posture in some acromegals.

The cranial skiagram (Fig 1) is of particular interest. The whole calvaria is thick, particularly in the frontal bone, the inner table of which is thicker and denser than normal, a sclerosing process apparently having extended from the inner table into the adjacent middle table, which seems to have undergone earlier some degree of "expansion."

The prominence of the supra-orbital ridges here seems to be related to the development of the frontal sinuses which, while not extensive vertically, are large in their lateral and anteroposterior diameters. The maxillary antra are large, as are the mastoid air cells. The whole face is well pneumatized and there is a

slight degree of prognathism, which is somewhat greater than is shown in the skiagram owing to part of the film having been cut off anteriorly. There is well marked synostosis of the coronal suture, which, in view of the patient's age, cannot be regarded as entirely normal. The sella turcica is normal.

A general clinical impression at that time seemed to warrant the provisional description of such a cranium as "sub-acromegalic," and we felt inclined to the view that during adolescence this patient had had a transitory hyperpituitarism which had manifested itself in his general body conformation as well as in his cranial proportions and structure.

At this stage it occurred to us that the recognition of such conditions might possibly serve as a "lead" to a wider concept of the main problem under study. Here was a psychotic patient, apparently free of organic disease, in whom there was some evidence of disturbed pituitary function, indicated by data acquired from objective physiological tests carried out over a period of seven months. This disturbance had been most profound when the psychosis was deepest, and as the findings approached normality the patient passed through a stage of psychiatric improvement, to relative recovery of sanity. Also, with a definite history of an emotional and mental change in the second decade of life, he had in that same decade as the result of his various growth processes acquired a bodily conformation which could not be regarded as "normal" in that it did suggest a definite, though slight, degree of acromegaly. Furthermore, stigmata of such processes in the past were recognizable in the cranial skiagram.

As a hypothesis it might reasonably be argued that his psychiatric condition might owe its fundamental etiology, perhaps in part, to abnormal functioning of those factors which regulate and control growth and development in the widest sense, in which must be included, not only bone and muscle, but also the central nervous system whose most highly evolved function,

quate number of cases, as well as the fullness of the studies already done, and the accessibility of the data. Of the first 1,000 patients studied, all of whom had been referred as possible endocrine cases, 40 per cent had been shown not to be endocrine and these would serve usefully as control material in checking findings. It was also an advantage that organic diseases, which might add a complicating factor, could largely be excluded, and the cases were referred from such a wide area and the various racial stocks were sufficiently present to provide a representative American population. But the chief advantage lay in the fact that whether or not, in the case of any individual, an endocrine factor could be demonstrated, at least he was "known" physiologically as to the degree of his normality or abnormality, which fact might subsequently aid in the evaluation of the possible significance of any such single datum as might have been found in the cranial skiagram.

The general plan of the investigation was to study all cranial skiagrams on file in the institution, without the identity or diagnosis of the case being disclosed to the examiners, who selected all those which seemed definitely to be dysplastic, stating the facts on which they based their opinion. The final diagnosis on record after one or more periods of physiological study was then added to the list of the dysplastic cases. This method seemed to be reasonably secure in its objectivity.

It was felt that, from the clinical cranio-logical viewpoint, postero-anterior and lateral cranial skiagrams should be as informative and as valid as projection or orthodiagraphic drawings of dried crania, on which to form an estimate of the differential growth record, beside giving an accurate impression of density and of architectural structure, whether normal or pathological. We were, of course, aware that distortions did arise due to radiographic technique, but a preliminary study of dried crania, which were measured both by micrometer calipers and on the skiagrams, made with a standard technic, convinced us that

these would not really invalidate this method of study.

There is, however, at first a twofold disadvantage in the use of the cranial skiagram for this purpose. Craniologists have not as a rule used x-rays in the examination of their material, so that there are certain omissions in observation of structure, and the radiographic changes concomitant to the conditions they describe have to be inferred. Also, in such an informative disease as acromegaly, much of the authoritative work on the changes produced in the skull had been done before current use was made of the skiagram as a diagnostic agent, so that accurate description of early change or change of slight degree is lacking. Full description had to await postmortem examination, by which time the disease had as a rule existed many years, with the possibility of factors either secondary to the pituitary condition, or even relatively unconnected with it, markedly altering the final picture.

Since our interest in cranial dysplasia had arisen from the "subacromegalic" type, our first attention was directed to the consideration of all the varying effects which acromegaly may produce on the cranium, both in its proportions and in its structure.

THE CRANIAL CHANGES IN ACROMEGALY

For a full appreciation of the possible variety of changes which the acromegalic process may produce in the human skull, we thought it desirable to review the findings recorded, from the first recognition of the condition as a syndrome associated with pituitary tumor by Marie, onwards, as cases were reported in the world literature. It should be borne in mind that although the later summarized descriptions of the pathological findings are more authoritative, being backed by a greater number of cases, they in no way contradict or diminish the value of the earlier observations as *findings*, although disagreement may arise with the interpretation put upon the findings, in offering

in six cases to a "well marked" extent. At this point it may be of interest to note that on June 8, 1932, when Dr A W Rowe reviewed the data on 32 cases, studied under the "seven-month plan" (3) at Worcester State Hospital, for the purpose of endocrine diagnosis, six of these 11 cases were included, unknown to Dr Rowe. Five of them he diagnosed as "pituitary dysfunction" and in the sixth he suggested the possibility of this condition as a factor in the case. Four of the cases showed abnormal growth of body hair, in two restricted to the sacral region, and in another it was so generalized and abundant as to give the patient a pithecoïd appearance. One patient was tall and described as "eunuchoid," while another, aged 16, was 179.5 cm in height, with a sitting height index of 0.511 and a history of rapid growth in the previous two years. His frame was powerful, with very large hands and feet. There was marked dorsal kyphosis and lumbar lordosis. The ears were "very large" and the lips "prominent and thick." The lower jaw was heavy and the general appearance suggested acromegaly.

It was, of course, obvious that a series of 11 cases was inadequate to indicate the possible frequency with which a dyspituitarism in the adult, recognizable physiologically, might correlate with an earlier dyspituitarism during the growth period, whose imprint on cranial form and structure would remain for subsequent recognition in the cranial skiagram.

While it might seem more reasonable to suppose that adult dyspituitarism would be most likely to occur in those whose glandular function during growth had been unstable, the possibility of the condition developing in cases in which the growth period had been uneventful had to be admitted. Nor could it be inferred from such a series whether or not a general disturbance of the endocrine control of somatic growth might be a fundamental factor in the later production of mental disability.

The problem seemed to formulate itself as three questions

(1) What is the frequency of occurrence, in a significantly large group of adults who are free of organic disease, of such individual variance from average cranial form and structure that the skull can be regarded as dysplastic?

(2) If, on the evidence already existing, the assumption is made that the pituitary gland plays a dominant rôle in the matter of cranial form and structure, what proportion of individuals manifesting cranial dysplasia can be shown independently to offer other evidence of pituitary disability?

(3) What is the frequency of occurrence of mental disability or disease in individuals who show both cranial dysplasia and physiological evidence of disturbed pituitary function?

In order to carry out the investigations necessary to answer these questions, it was decided to continue the inquiry at the Evans Memorial Hospital, in Boston, where for many years Rowe (4) and his co-workers had been engaged in studying the physiologic data acquired from a large series of patients referred for endocrine diagnosis, and had in use a diagnostic method based on a preliminary comprehensive general medical examination of the patient, amplified by a large series of objective tests by which the individual's physiologic function level could be estimated.

There were then on file very complete records of 4,000 cases studied by this method, which included lateral and postero-anterior cranial skiagrams of 3,000 of them, all of which had already been "read" by one of us (G L.) and his opinion recorded. This group included both sexes, children and adolescents as well as adults. The fact that such a group constitutes a special or selected population has certain advantages, which outweigh the inherent disadvantage that figures so derived are probably not applicable to either an ordinary healthy population or even to a general hospital population.

The advantages lie in the quite ade-

anthropological sense of projection of the masticatory framework in front of the forehead, when the skull is orientated in the Frankfurt plane. He disapproved of the use of the word by contemporary French writers to describe the condition in which the teeth of the lower jaw project beyond those of the upper, and prefers to use for this latter condition the more correct term suggested by Ludwig Meyer in 1868 (16), who grouped skulls, showing this deformity from a variety of conditions, under the title "*Crania progenea*"² or, in colloquial German, "*progenee Schädel*"

Amongst more recent English writers there has been a tendency to use the Latin adjective as an English noun (17). The original derivation is from the Greek *προγενέας*, *prominent chin*, *progenium* being the permissible latinization. In English, the noun from this would be "progenity" or "progenism" and the adjective "progenetic", all are awkward terms. Better words can be got in English by direct derivation from the Greek—"progeniac" the adjective, and "progeniacism" the noun, both of which aptly express the anatomical condition in regard to which they are most applicable.³

Sternberg also notes the "sclerotic hypertrophy" of the vault of the skull described by Thomson (18), and draws attention to the changes arising "from the marrow of the bones, especially those in which, during growth, the marrow remains preserved," quoting Duchesneau's

case (19), of which the skull is an example, in which resorption may predominate and even be extreme. He pointed out that, in general, the medullary spaces between the osseous septa are enlarged, but that these latter may themselves be hypertrophied. Thus, depending on whether the periosteal or myelological changes predominate, the compact bone may be thickened at the expense of the cancellous part, or the cancellous may be very vascular and over-developed, with the compact bone extremely thin (20).

Finally, it is clear that Sternberg considered the cranial changes to be the result of the primary changes in the jaws. He says

"The strong formation of the masticatory apparatus demands powerful points of compensation in the head. These come about either by thickening of the solid or through dilatation of the hollow supports, or through distribution of the weight over a large surface. To the first the hypertrophic zygomatic arch corresponds, to the second the dilatation of the air sinuses, and the increase of the skull to the third. All changes in the form of the skull thus stand in causal connection."

In 1911, Keith (21), dissatisfied with "the empiricism of craniological methods" and aware of the necessity of "applying more rational principles to the elucidation of the problems of head form," sought in the study of acromegalic crania "a clue to some of the circumstances which determine the shape of the head and face." At that time he estimated that there were records of some 400 cases of acromegaly, "yet nowhere was there to be found an exact inquiry into the nature of the growth changes of the skeleton, particularly of the skull."

Keith had access to some twelve acromegalic crania, all of which he studied, and from a detailed analysis of six of them he made good the lack on which he had commented, by a classic study, which not only demonstrated the nature and significance of the acromegalic changes, but justified his conclusion that these changes, essentially of the nature of true growth, were similar to those conditions that normally are to

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At close quarters, Maiden, do I appear to you to be
snub nosed and long-chinned? You will make me
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explanation of the mechanism of production of the deformities noted during life

Marie (6) described the cranial changes seen in his cases as follows

"The cranium is but little altered in shape and size, or at least its alterations are not obvious. The forehead is usually rather low, with a very marked prominence of the orbital arches (due especially to the dilatation of the frontal sinuses). The cheek bones rather prominent and bulky (not from hypertrophy of the malar bone, but from dilatation of the maxillary sinuses), this prominence is in part masked by the elongation of the face. The chin projects markedly forward and downward, it is large and massive, moreover, the lower jaw is altogether considerably increased in size, and as the upper jaw does not undergo the same modifications, a very marked degree of prognathism often ensues. The teeth undergo no modification in size, but in consequence of the enlargement of the lower jaw they are here seen to be separated a little from one another. The bones of the cranium and face are the seat of a more uniformly distributed hyperostosis (or rather the increase in size is due much more to the dilatation of the frontal sinuses than to a true hyperostosis), without the formation of osseous tumors or definitely circumscribed bosses. The results of the examination of the skeleton of my patient by my friend Dr. Auguste Broca (7) have shown us that it is especially the spongy tissue which is the seat of the hypertrophic processes."

As the syndrome received increasing attention and fresh cases were reported—Souza-Leite (8) had collected 38 cases in 1890—it became evident that the skull might not always undergo the classical deformity. Marie also had recognized less well-marked cases, which he called "formes frustes," as well as a variety in which the lower jaw is not enlarged—and might even appear small in comparison with the upper jaw—which he called the square variety ("type carrée") in contrast to the classical "ovoid" appearance of the face (9). Similar observations had been made by others (10, 11, and 12).

In 1897, Sternberg, the Viennese pathologist, published his monograph (9) on acromegaly, collecting data from 210 cases in the literature at that time. In summarizing the pathological changes in the osseous system as they affect the skull, he

points out that there have been cases in which the brain itself has been enlarged as a whole (13 and 14), calling for an increased cranial capacity and hence enlargement of the skull. But apart from this, the skull is frequently enlarged, coarse, and heavy, with thick walls, especially if the disease has lasted a long time. Its circumference may or may not be increased. Muscular attachments are apt to be overgrown and prominent, especially the external occipital protuberance, the mastoid processes, and the styloid processes of the temporal bones.

Small exostoses may occur on the wall of the aqueductus vestibuli and, more rarely, on the upper surface of the sphenoid bone. There may be deformity of the clinoid processes, and the sella turcica may be widened in all directions, *or, on the other hand, it may be normal*. The vascular channels on the inner surface of the skull are deepened, and the arterial and venous foramina enlarged.

The air sinuses are enlarged, although not all to the same extent. The frontal sinus extends higher up into the diploe of the bone, so that the usual saw-cut, in the horizontal plane of the skull, 1 cm. above the orbital curve, opens into the sinus. If the expansion of this sinus is marked, even although the anterior wall is thin, it may markedly alter the shape of the forehead, a deformity which may be increased, in other cases, by hypertrophy of the bone. A similar condition may be found in the mastoid cells and maxillary antra as well as in the ethmoid capsule. Bulging of sinus walls may cause neighborhood deformity, the orbit may be narrowed by expansion of ethmoid cells, of the lower wall of the frontal sinus, or of the upper wall of the maxillary antrum. Such expanded sinus walls may be paper thin, or, on the other hand, they may be thick, a change which he attributed to long duration of the disease. The maxillary alveolar process may be hypertrophic, and still more so the body and ramus of the mandible, and the conditions of prognathism, alveolar prognathism, or prognathism thus produced (15). Sternberg used the word "prognathism" in its correct

anthropological sense of projection of the masticatory framework in front of the forehead, when the skull is orientated in the Frankfurt plane. He disapproved of the use of the word by contemporary French writers to describe the condition in which the teeth of the lower jaw project beyond those of the upper, and prefers to use for this latter condition the more correct term suggested by Ludwig Meyer in 1868 (16), who grouped skulls, showing this deformity from a variety of conditions, under the title "*Crania progenea*"² or, in colloquial German, "*progenee Schädel*"

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be found in anthropoid and neanderthaloid crania, and which he suggested are due to probable hyperpituitarism.

He thought the evidence that there might be an actual increase in cranial capacity was inconclusive. Taking the normal adult male calvarial thickness as varying from 5 mm to 7 mm and quoting Biddle (22) to the effect that a thickness over 12 mm was to be regarded as pathological he found that, in the vault of the skull, the frontal region was the part first and most affected. In six cases the frontal bones varied from 6 mm to 15 mm, a range which was also found in the parietal region. The change affected only that part of the calvaria bounded by the temporal lines on each side so that a 'sagittal bar' of thickened bone was formed, which rested in front on the supra-orbital bar, and behind on the external occipital protuberance. He considered this change comparable to the growth of the sagittal crest in the gorilla, the function of which was to act as a "fulcrum or origin" for the temporal muscles. This formation could be 'correlated to the masticatory changes' in the acromegalic.

A point of great importance was that the calvaria also varied in structure. In two cases the bones of the vault were thickened and porous, as in osteitis deformans, two showed thickening but with the inner and outer tables retained, while in the remaining two the bones were of normal thickness but were increased in density. In all six the inner table of the frontal bone especially above the orbital plates, showed the tendency to the formation of small dense osteomas, and a similar condition was found within the frontal sinuses. Throughout the osseous system as a whole, and in the skull in particular, the small vascular foramina were opened out, and there was an increase in size of the venous sinuses.

In the occipital region of the skull were the following changes. The nuchal muscle area was increased in extent, and the external occipital protuberance, not only increased in size by bony deposit, but also moved upward a distance of from 8 to 10

mm. A most significant observation in this region was the relative displacement of the foramen magnum. Hypertrophy of the basilar part of the occipital bone displaced the foramen backward in giant acromegalics, while atrophy of this part, in non-giant acromegalics, moved the foramen forward. Also, in the late and atrophic stages of the disease, the head might be carried more extended on the neck, owing to change in shape of the occipital condyles.

There was great supra-orbital growth, with thickening of the bone and expansion of the frontal sinuses. The whole orbital region grew forward, owing to the great temporal development, which was due to or coincident with the great changes that took place in the mandible. Above, this forward orbital growth could be seen in the distance of the cribriform plate to the glabella, which, normally 14 mm, might become 25 mm, and below, where the external angular process of the frontal bone and the ascending process of the malar bone might come to occupy a position 10 to 15 mm farther forward and downward than normal. From these changes resulted the large prominent nose in acromegaly.

The zygomatic arch was increased in depth and lowered in its relationship to the cranial cavity. The normal inter-zygomatic diameter of 130 mm might be increased to 154 mm, and the external auditory meatus was also lowered. By such means the temporal fossa was greatly increased in size, as was also the area of origin of its contained muscle—in an upward and backward direction on the parietal bone 10 to 25 mm more than normally the case. But it was the forward extension of the temporal muscle origin that was the most striking, for he found that the temporal ridge might be carried forward till it lay on a plane anterior to the anterior pole of the brain, instead of being, as normally, 15 to 20 mm posterior to that plane. He concluded that this was the cause of the forward growth of the orbital region.

The inter-orbital distance might be increased from 3 to 5 mm and the outer or-

bital wall might move outward and downward from 8 to 10 mm

The upper face (nasion to maxillary alveolar margin) he found increased in length, and might be 90 mm instead of the normal 70 mm. Thus, however, was made up in great part by alveolar growth

The symphysis of the lower jaw was increased in depth and, summarizing the facial deformity, he said "The total increase in face length is about 20 mm, the increase from one angle of the jaw to the other rather less (than 20 mm) "

Keith found that the area of the palate is not increased in acromegaly, and may be even diminished, especially the palatal area of the lower dental arcade. In the lower jaw the width between the last molars was increased, in the mean 10 mm. The lower canine teeth were advanced till they were nearly in line with the upper incisors. An increase in porous vascular bone on the alveolar margins separates the teeth, and adds to palatal height

In the mandible, the changes in the body of the bone were growth of the alveolar margin, growth at the mental eminence, and growth of the body of the bone, anterior to the groove for the facial artery. The chief changes, however, took place in the ramus. It became narrower and longer. Resorption occurred at the angle, producing the well-known "opening out" and bone was resorbed from the inner and deposited on the outer aspect of the angle, so that the ramus seemed to move apart. The mandibular ramus became lengthened by growth which took place at the condyle, coronoid process, and sigmoid notch. The floor of the glenoid cavity was thickened and the articular eminence diminished

The foregoing summary of the various features of cranial pathological anatomy in acromegaly, to which pathologists and anatomists had called attention in the past, forms a sound guidance for the radiologist. However, we thought it essential, if we were to be certain of the truth of subsequent radiographic interpretation of minor degrees of change, that a preliminary study be done on documented, museum

acromegalic crania, so that comparison could be made between the structure and dimensions of the dried skulls in reality and the data obtainable from the skiagrams of those skulls. It was also most desirable to study as many varieties and combinations of the pathologic changes as possible, and there were technical advantages in first examining dried crania, in that finer bone detail could be got than in cases of living subjects with the disease

In addition, there was the decided advantage of making available, as standards for the radiologist, skiagrams of crania the study of which, both by the anatomist and the pathologist, had formed the foundations of our knowledge of the pathologic processes in this disease, as they affect the skull

We were aware, of course, that such material would be by no means abundant, even though Atkinson (23), in 1930, after a laborious search of the world literature, had been able to find 1,319 cases of acromegaly, in 265 of which postmortem reports had been made. But we were not prepared to find such material so scarce as it subsequently proved to be. Twelve of the leading American anatomical and pathological museums, where large collections of crania were known to exist, were communicated with, while widespread inquiries were made about such material in universities and medical schools

Only four acromegalic crania could be found in the United States. Two specimens (No 1784 and No 61) are from the Warren Museum, Harvard Medical School. These are of two patients of Dr Harvey Cushing and the postmortem findings have been fully described (24). One specimen (No 1145 00) is in the Mutter Museum, Philadelphia, while the fourth is in the Museum of the Department of Anatomy, University of Chicago, this is the skull of Dr Dean Lewis' case (25)

To the curators of these museums we are deeply indebted for the opportunity given us to radiograph and study these specimens

To the Curator of the Museum of the Royal College of Surgeons of England we

be found in anthropoid and neanderthaloid crania, and which he suggested are due to probable hyperpituitarism.

He thought the evidence that there might be an actual increase in cranial capacity was inconclusive. Taking the normal adult male calvarial thickness as varying from 5 mm to 7 mm and quoting Beidler (22) to the effect that a thickness over 12 mm was to be regarded as pathological, he found that, in the vault of the skull, the frontal region was the part first and most affected. In six cases the frontal bones varied from 6 mm to 15 mm, a range which was also found in the parietal region. The change affected only that part of the calvaria bounded by the temporal lines on each side so that a 'sagittal bar' of thickened bone was formed which rested in front on the supra-orbital bar, and behind on the external occipital protuberance. He considered this change comparable to the growth of the sagittal crest in the gorilla, the function of which was to act as a 'fulcrum of origin' for the temporal muscles. This formation could be 'correlated to the masticatory changes' in the acromegalic.

A point of great importance was that the calvaria also varied in structure. In two cases the bones of the vault were thickened and porous, as in osteitis deformans; two showed thickening but with the inner and outer tables retained, while in the remaining two the bones were of normal thickness but were increased in density. In all six the inner table of the frontal bone especially above the orbital plates, showed the tendency to the formation of small dense osteomas, and a similar condition was found within the frontal sinuses. Throughout the osseous system as a whole, and in the skull in particular, the small vascular foramina were opened out, and there was an increase in size of the venous sinuses.

In the occipital region of the skull were the following changes. The nuchal muscle area was increased in extent, and the external occipital protuberance, not only increased in size by bony deposit, but also moved upward a distance of from 8 to 10

mm. A most significant observation in this region was the relative displacement of the foramen magnum. Hypertrophy of the basilar part of the occipital bone displaced the foramen backward in giant acromegalies, while atrophy of this part, in non-giant acromegalies, moved the foramen forward. Also, in the late and atrophic stages of the disease the head might be carried more extended on the neck, owing to change in shape of the occipital condyles.

There was great supra-orbital growth, with thickening of the bone and expansion of the frontal sinuses. The whole orbital region grew forward, owing to the great temporal development, which was due to or coincident with the great changes that took place in the mandible. Above, this forward orbital growth could be seen in the distance of the cribriform plate to the glabella, which, normally 14 mm, might become 25 mm, and below, where the external angular process of the frontal bone and the ascending process of the malar bone might come to occupy a position 10 to 15 mm farther forward and downward than normal. From these changes resulted the large prominent nose in acromegaly.

The zygomatic arch was increased in depth and lowered in its relationship to the cranial cavity. The normal inter-zygomatic diameter of 130 mm might be increased to 154 mm, and the external auditory meatus was also lowered. By such means the temporal fossa was greatly increased in size, as was also the area of origin of its contained muscle—in an upward and backward direction on the parietal bone 10 to 25 mm more than normally the case. But it was the forward extension of the temporal muscle origin that was the most striking, for he found that the temporal ridge might be carried forward till it lay on a plane anterior to the anterior pole of the brain, instead of being, as normally, 15 to 20 mm posterior to that plane. He concluded that this was the cause of the forward growth of the orbital region.

The inter-orbital distance might be increased from 3 to 5 mm and the outer or-

"The orbits are large (height and width, 46 mm) and the distance between their inner walls increased. The bi-zygomatic diameter of the face is 147 mm (normal, 130 mm). The superior maxilla is increased in size, especially in the vertical direction.

"The lower jaw is greatly elongated, measuring 168 mm from the condyle to the point of the chin, and the lower alveolar border with its teeth projects beyond the upper, in the incisor region. The lower incisor teeth are widely separated. The increased size of the jaw is mainly due to enlargement of its body, both in length and thickness, the rami are relatively unaltered, except for considerable lateral enlargement of the condyles.

"The symphysis measures 48 mm. The angle formed by the ramus and the body is more open than normal. The length of the hard palate is 67 mm, its width between the outer surfaces of the bone, at the level of the second molar teeth, is 70 mm. The tuberosities of the palate bone are hypertrophied."

The lateral skiagram of this skull (Fig 2) gives a clear illustration of the foregoing description, and, in addition, it demonstrates the nature of the structural changes in the bones of the cranium and face. Clearly, this is a relative increase in cancellous bone, produced by an "expansion" of medullary spaces, resorption having been dominant while bony deposition was diminished, variable in amount, and irregular in situation.

In the vault this change manifests itself as "diploic expansion." The frontal bone is most affected, the parietal bone, as it is followed backward, decreasingly so, while the occipital bone, except for considerable thickening in the region of the lambda and external occipital protuberance, is least affected. The upward (backward) displacement of this last structure is clearly seen.

The frontal sinuses are very large and the degree of their extension into the orbital roofs is clearly evident. Their anteroposterior dimensions explain the superciliary bulging, already referred to, which almost angulates the frontal bone outline at the upper limit of the sinus, doing much to produce the appearance of a receding brow.

The sphenoidal sinuses have been ob-

literated—the tumor had invaded them during life, and operation had not been done—and there is well marked sclerosis of the floor of the middle fossa. The petrous portion of the temporal bone is abnormally dense, and the destruction of the sella turcica is evident. The mastoid cells are large and the mastoid process demineralized, for which reason it shows up poorly in reproductions of the skiagrams.

The maxillary antra are large and extend in the hypertrophic alveolar processes far below the level of the nasal floor.

The mandible shows a general demineralization, with large expanded medullary spaces in the body, and even more marked expansion in the mental process, which is abnormally prominent. This cranium while not prognathic, is slightly progeniac.

A subvariety of this type, which we call Type 1, A, occurs when expansion changes predominate in the brow and face, without such change markedly affecting the vault of the skull, the calvaria showing either a relatively normal structure or, more usually, actual thinning of the bone, with or without slight relative increase in diploe. There would seem to be a tendency for this to occur when the disease runs a rapid course in the young, or it may occur as an atrophic form, in the late stage of the disease.

Such a skull is No 3,861-2 (Fig 3) in the Museum of the Royal College of Surgeons, London, presented in 1931 by the London School of Clinical Medicine, and previously described in detail by Keith (21) as the "Greenwich Skull," from which paper and the Museum Catalogue the following is quoted:

"The skull of a male acromegalic between 50 and 60 years. The facial part of the skull is markedly increased vertically, the nasion to the upper alveolar margin is 82 mm (normal 70 mm), the bones concerned in the increase being the superior maxilla and the ramus of the lower jaw. The angle of the lower jaw is well marked and in no way opened out or widened. The anterior nares are increased in size from above down, and the hard palate is high. The nasal bones are prominent, but there is no abnormal forward projection of the alveolar



Fig 2 No 3,860-1, Royal College of Surgeons' Museum, London Case presented by Dr Frank Corner, 1912 Patient was male, aged 42 years, who died of acromegaly of over 17 years' duration

are similarly indebted for the opportunity to study and radiograph six specimens, four of which were fully described by Sir Arthur Keith in 1911 (21)

To Professor J C Brash, Edinburgh University, we owe the opportunity to examine the cranium of the case reported by Cunningham (26), the skeleton of which was described by Thomson (18) The skiagram of this skull we owe to the courtesy of Dr Duncan White

Thus we have 11 documented specimens of acromegalic crania for roentgenologic examination We shall describe them from the radiologist's standpoint, adding such clinical and descriptive data from other sources as will enable the reader to gain a more accurate idea of their condition

For descriptive purposes we have found it convenient to arrange them in three major groups or types, according to the general picture of change observable in them

Type 1—This type is characterized by a generalized and marked degree of "expansion" of the medullary cancellous tis-

sue of the bones of the cranium and face, with marked enlargement of those structures normally developed in the cancellous tissue of certain bones—the paranasal and mastoid air cells In this type the resorption of bone has been very active, but deposition has at least succeeded in preserving the architectural structure, especially in the calvaria, so that the three tables of bone can clearly be made out, with a marked relative, as well as absolute, increase in diploe, and at least some rarefaction

Figure 2 is the lateral skiagram of specimen No 3,860-1, presented to the Museum of the Royal College of Surgeons, London, in 1912, by Dr Frank Corner The following facts are from the Museum Catalogue The patient, who died of acromegaly at the age of 42, showed well marked signs of the disease at the age of 25 years, and was bedridden during the last ten and a half years of his life Most of the bones of the limbs show signs of osteoarthritis His height, measured after death, was 1,843 mm (6 ft 0 5 in)

"The facial portion of the skull is relatively large as compared with the cranial portion, the main increase being in a vertical direction. The superciliary region projects prominently forward, the distance from the middle of the external auditory meatus to the glabella being increased (145 mm), and also the length of the cranium 203 mm The superciliary projection produces the effect of a receding forehead, but otherwise the cranium is fairly normal in size and form (circumference, 568 mm , breadth, 147 mm , height, 130 mm) The temporal lines are situated high up on the parietal bones, those of the opposite sides approaching to within an inch, immediately behind the bregma. The tympanic plate is thick. The mastoid process is large and its muscular attachments well marked The occipital condyles are flattened and surrounded by ridges of new bone, resulting from osteo-arthritis The frontal sinuses are expanded, and the two tables of bone forming the roofs of the orbits are widely separated in the greater part of their extent The central part of the middle fossa is greatly deformed by the pituitary tumor The pituitary fossa cannot be recognized, the body of the sphenoid bone is reduced to a narrow, median bony ridge and the sphenoid sinuses are almost completely obliterated

"The orbits are large (height and width, 46 mm) and the distance between their inner walls increased. The bi-zygomatic diameter of the face is 147 mm (normal, 130 mm). The superior maxilla is increased in size, especially in the vertical direction.

"The lower jaw is greatly elongated, measuring 168 mm from the condyle to the point of the chin, and the lower alveolar border with its teeth projects beyond the upper, in the incisor region. The lower incisor teeth are widely separated. The increased size of the jaw is mainly due to enlargement of its body, both in length and thickness, the ramus are relatively unaltered, except for considerable lateral enlargement of the condyles.

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A subvariety of this type, which we call Type I, A, occurs when expansion changes predominate in the brow and face, without such change markedly affecting the vault of the skull, the calvaria showing either a relatively normal structure or, more usually, actual thinning of the bone, with or without slight relative increase in diploe. There would seem to be a tendency for this to occur when the disease runs a rapid course in the young, or it may occur as an atrophic form, in the late stage of the disease.

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Fig 3 (above) No 3 861-2, Royal College of Surgeons' Museum London presented by the London School of Clinical Medicine 1931. Previously described by Sir Arthur Keith (1911) as the Greenwich Skull. Patient was adult male acromegalic, aged between 50 and 60 years. Note the thinned calvaria with relatively slight increase in diploe and the increased density in the frontal part.

Fig 4 (below) No 3 864-1, Royal College of Surgeons' Museum, London, presented 1931, by the London School of Clinical Medicine. Skull of young male acromegalic. Note the thinned calvaria with relatively well marked diploe.

processes, either of the upper or lower jaw, or of the chin. The frontal sinuses are large and the glabella and superciliary ridges promi-

nent (The distance from cribriform plate to glabella is 25 mm, the normal is 14 mm).

"The cranium is not greatly altered in shape, the cranial bones are thin—(frontal bone, 6 mm, parietal, 8 mm) and the sagittal and lambdoid sutures are closed. There is a 20 mm increase in the inter-zygomatic measurement, the cranial capacity is normal—1,500 cc. The nuchal muscle area is increased by 2,200 sq mm. The sella turcica is enlarged measuring 21 mm, anteroposteriorly, 33 mm laterally, and 11 mm deep."

As this specimen could not be dismounted for radiography the lower jaw could not be clearly shown.

The skiagram (Fig 3) shows the marked hyperpneumatization of the brow and face and the backward extensions of the frontal sinuses along the whole length of the orbital roofs, with the well marked sellar expansion. The thinness of the skull is very evident, but the diploe can be distinctly seen, especially in the frontal bone which is somewhat thicker and denser than the rest of the vault.

Another "Type 1, A," skull is No 3,864-1, from the Museum of the Royal College of Surgeons, London, presented by the London School of Clinical Medicine (Fig 4). The Catalogue states

"a young Jew, the subject of acromegaly. The shape of the cranium is altered, being increased in width, more especially in the parietal region, and flattened from above down through elevation of the base (of the skull). The osseous tissue of the calvaria is thin, the diploe being almost entirely absent. A thin deposit of new bone covers the inner surface in the middle line and over the adjacent surfaces of the parietal bones. The sutures are ankylosed. The pituitary fossa is enlarged an inch, anteroposteriorly, and one and a half inches between the anterior clinoid processes. The internal base is flattened and increased in width, in the region of the middle and posterior fossae. Small bony deposits are present in the middle fossae. There is bony ankylosis of the cranium and atlas in almost its whole circumference.

"The facial part of the skull is elongated vertically, the nasal bones and the ascending processes of the superior maxillae are prominent, the anterior nares increased in vertical measurement and the margin of the upper jaw markedly projecting. The condyles of the lower jaw are abnormally wide and, owing to

the increase in size of the whole bone, their distance from the symphysis is increased to six and a half inches. The alveolar border is much atrophied and everted. The angle (of the mandible) is only slightly marked, the ramus and body of the jaw being very slightly inclined to each other."

The skiagram (Fig 4) shows the calvaria to be very thin and demineralized with, however, a certain amount of diploe, especially in the frontal bone. The frontal sinuses are large and extend about half way back in the orbital roofs. The nasal bones are long. The expansion of the sella turcica is marked and there is well marked density of the middle fossa of the skull, and of the petrous pyramids. The mastoid processes are long and finely porous in appearance throughout. The maxillary antra are surprisingly normal in size in view of the general deformity of the face and the forward projection of the upper alveolar process is clear. The mandible shows a profound change and is extremely disproportionate to the maxillæ. The angle is very open, the mental process is very projecting, and the whole bone very demineralized.

Also in this category belongs specimen No 1145 00 in the Mutter Museum, Philadelphia, which we owe to the courtesy of Dr Shenck. The skeleton is described as that of a "giant," and it is obviously from an acromegalic subject. The patient was 23 years old. His height is said to have been 2.30 meters, but this was considerably reduced by the lateral curvature of the spine. The femur is 65 cm, the tibia 55 cm, and the humerus 47.5 cm long. The antero-posterior diameter of the chest is 43 cm, and none of the diaphyseal cartilages are ossified.

The cranium is very large, its capacity being given as 2,320 cc. The skiagram (Fig 5) shows that although the face is large, it is relatively proportionate to the very large brain-case. The calvaria is very thin and the diploe poorly seen, there being a moderately well marked sclerotic change, especially in the frontal bone. In view of the open epiphyses elsewhere it is



Fig 5 (above) No 1145 00 Mutter Museum, Philadelphia. Patient was acromegalic giant male, aged 23 years. Note the thinned calvaria and synostosis of coronal suture.

Fig 6 (below) No 61 Warren Museum, Harvard Medical School, presented by Dr Harvey Cushing. Patient, G B S male aged 35 years. Acromegaly (chromophilic adenoma) 15 years. Note the calvaria is thinner in the frontal region.

interesting to note the bony synostosis of the coronal suture, which must be re-



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Fig. 4 (below) No 3,884-1 Royal College of Surgeons' Museum London, presented 1931 by the London School of Clinical Medicine. Skull of young male acromegalic. Note the thinned calvaria with relatively well marked diploe.

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interesting to note the bony synostosis of the coronal suture, which must be re-

garded as abnormal at the age of 23, and the somewhat spread lambdoid suture. The mastoid cells are both large and numerous, the petrous pyramid is dense, as is also the floor of the middle fossa.

The sella turcica is markedly expanded in the anteroposterior diameter, which may or may not have been due to an intrasellar tumor. From the appearance of the posterior clinoids, being somewhat drawn backward, the possibility does arise of an extra-sellar tumor producing this deformity by tension on the tentorium.

The frontal sinuses are enormous and extend far back in the orbital roofs, their walls are thin and very compact. They produce also a marked superciliary bulging, clearly evident over the root of the nose. The sphenoidal sinus is large and the maxillary antra abnormally so. The alveolar margin of the upper jaw is projecting, the mandible shows well marked prognathism, the angle is moderately opened out, and more than a little demineralized.

In addition, the skeleton of this case showed well marked osteo-arthritic changes, especially at the hip joints.

We have also placed in this group (Type 1, A) specimen No. 61 in the Warren Museum, Harvard Medical School (Fig. 6), one of the cases described by Cushing and Davidoff (24). The patient, G. B. S., a male, died at the age of 35 after 15 years of acromegaly. Pathologically, there was a chromophilic pituitary adenoma, with hypertrophy of the thymus, and adenomas in the thyroid, parathyroids, pancreas, and adrenals. The testicles were atrophic. He was 5 ft 8 in in height, and at one time had weighed 220 pounds. There was considerable adiposity and diabetes was uncontrollable.

The cranial skiagram shows that there is considerable elongation of the face but that the brain-case is by no means large. Anteriorly, the calvaria is thin, with a diminished diploic table, with considerable obliteration of the normal architectural structure by sclerotic change, which still more affects the parietal and posterior

parts, where the calvaria is considerably thicker. For this reason the cranium might have been classed with the next type, but we have preferred to include it as a Type 1, A, because of the definite thinning of the frontal bone. This cranium weighed 485 gm, a point to which reference will later be made.

The frontal sinuses are large and extend well back into the orbital roofs. There is extensive damage to the sella turcica, the face is hyperpneumatized and elongated, the mandibular ramus are very long, the angle is opened out, the mental process is expanded, and there is a marked demineralization of the face. The cranium is prognathic.

Another Type 1 specimen is No. 3,863-1, in the Museum of the Royal College of Surgeons, London, presented by C. F. Beadles in 1907, having been described by him in 1898 (22) and later by Keith, in 1911 (21).

"The patient, a huge bony woman, had died insane at the age of 40. She had large zygomatic processes, prominent superciliary ridges, and a receding forehead. The ears and lower jaw were immense, and she had spade-like hands and enormous feet. At autopsy it was noted that the body was very obese, the bony skeleton was huge, the thyroid was hypertrophied, and there was a cystic tumor of the pituitary, the size of a hen's egg, with great deformity of the sella.

"The calvaria is shallow and small and its bones unevenly thinned, in some places to the extent of being quite translucent. As one passes back, it tends to become thicker, and, at the posterior end, the specimen is a little over $\frac{1}{4}$ in thick. In the thinned parts no diploe exists, in the thicker and hunder part the whole width seems composed of finely porous cancellous tissue. The coronal and sagittal sutures are distinct. Growing from the inner table of the frontal bone are a number of small dense bony outgrowths, of the nature of exostoses.

"The vault is very shallow, its highest point, only one inch behind the bregma, is scarcely two inches above the line of section (of the skull cap). The frontal bone presents most peculiar changes. The forehead is very depressed and receding, there being no frontal eminences, it slopes gradually upward and backward to the coronal suture. The tem-

poral crest stands out prominently, giving a broad square contour to the forehead it resembles the frontal region of the skull of an Australian aborigine, or that of one of the higher apes

"There is an enormous distention of the frontal sinuses For four inches across, the tables of the frontal bone are separated for a distance of an inch, both tables being exceedingly thin and translucent The sinuses extend to within one and a half inches of the coronal suture The weight of the dried skull cap is only 5 oz "

The skiagram (Fig 7-B) in the postero-anterior view, shows the enormous extent of the frontal sinuses, the great prominence of the temporal crests, which form the lateral margins of the sinuses, and the general simian appearance of the skull cap The lateral view (Fig 7-A) shows synostosis of the coronal suture, the very thin sinus walls, and the very thin inner and outer tables, the greater part of the thickness in both the temporal and parietal portions of the vault being made up of very finely porous diploe Keith gave the frontal and parietal calvarial thickness in this skull as 6 mm in both regions

To Type 1 also belongs the cranium of a skeleton in the Museum of the Department of Anatomy, University of Chicago We owe this skiagram to the courtesy of Professor R R Bensley

In 1931 this was a patient of Dr Dean Lewis and a description of the skull was given by Bassoe (25) in 1922

"He was a man of 40, 6 ft 2 in in height, and weighing 250 pounds The circumference of the head was 635 mm, the binauricular arc 390 mm, and the distance from glabella toinion 400 mm All sutures are obliterated The superciliary ridges are markedly prominent the external occipital protuberance, the mastoid processes and the superior nuchal lines also show marked bony overgrowth The frontal, parietal, and occipital bones show hypertrophy which is greatest in their mesial portions, while the squamous portions of the temporal bones, and the greater wings of the sphenoid show no hypertrophy and are thinner than normal The under surface of the base shows marked bony irregularities, at the seat of muscular and ligamentous attachments The foramen magnum is encroached on by bony exostoses at the margin A horizontal section of the skull shows thin



Figs 7-A (above) and 7-B (below) No 3,863-1, Museum of Royal College of Surgeons, London, presented by C F Beadles in 1907, described by him in 1898 Calvaria of insane female aged 40, the subject of acromegaly

external and internal tables with marked thickness of the diploe, both posteriorly and anteriorly and enormous dilatation of the frontal sinuses which measure 5 cm from above downward

"A sagittal section of the vault shows a uniform thickness of 15 mm with thick diploe and thin tables The internal surface of the vault is markedly roughened, and shows a large number of flattened wart-like excrescences especially abundant along the middle line the sella turcica measures 36 mm anteroposteriorly the dorsum sellæ and posterior clinoids are destroyed, except for a small ridge at the base the floor of the sella is destroyed and communicates with the sphenoidal sinus

"The antra are greatly reduced in size The alveolar processes and teeth are approximately normal The malar bones and zygomatic processes are normal The palate is markedly deepened, its roof very thin and narrowed in the transverse diameter the inferior maxilla shows marked prognathism There is marked elongation of the ramus and the angle is widened by 15 or 20 degrees There is moderate bony overgrowth of the margins of the symphysis of the chin, with a grooving of the anterior surface of the symphysis The thickness of the body and the ramus is considerably reduced, especially from groov-



Fig 8 Cranium of acromegalic male from Museum of the Department of Anatomy University of Chicago. Skiagram by courtesy of Professor R. R. Beasley.

ing along the mesial surface. The condyles, necks, and coronoid processes are normal."

The lateral skiagram (Fig 8) shows a "large" skull with a greatly elongated face. The frontal sinuses are huge, especially in their antero-posterior dimension, without extending to any great degree into the orbital roofs. They cause considerable supraciliary bulging. One half of the calvaria is missing, and in the remaining half the structure of the bone is clearly seen. Of the 15 mm. of bone which constitutes the calvarial thickness, about nine-tenths is seen to be composed of a finely porous diploe, the inner and outer tables being very thin. The thickest part is just above the frontal sinuses, and the calvaria diminishes slightly in thickness as it goes backward, the occipital part being the least affected. There is marked bony deposit on the external occipital protuberance. The mastoid processes are large and contain numerous large air cells, especially at the tip.

Damage in the middle fossa has largely obliterated the sella turcica and the sphenoid sinuses. The antra are not di-

lated. The palate is high, especially behind, and there is forward projection of the incisor portion of the maxillary alveolar process.

The skull is markedly prognathic, with elongation of the ramus and body of the mandible, which have undergone cancellous expansion and atrophy by resorption; the mental protuberance is markedly expanded and projects forward beyond the body of the symphysis. The angle of the jaw is much opened out. There is hyperplasia of the mandibular alveolar process, especially in front.

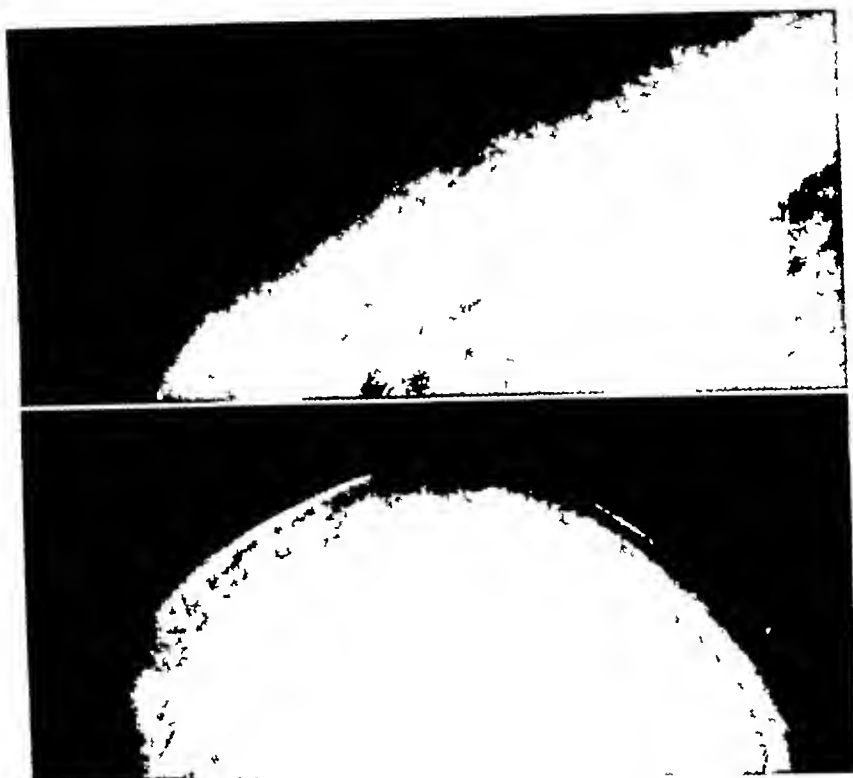
The changes in this cranium are very closely similar to those found in the cases of Rowe and Mortimer (27) and Scriver and Bryan (28), both of which are Type 1 (Fig 9-B).

Type 2—Of the second group of acromegalic crania there are three specimens. The characteristic feature of this type is that, apparently having undergone initial changes similar to Type 1, there has subsequently occurred an excessive deposit of bone. It will have been noted, in the description of Type 1 crania, that the tendency is toward demineralization of the expanded cancellous bone, and that such deposition as does occur tends to be irregular and to favor certain sites. On the whole such crania are relatively light in weight for their size, and sometimes they are absolutely so, for resorption is dominant; in Type 2 deposition is dominant and extremely heavy skulls may be produced.

The increased density or "sclerosis" thus produced, appears in the skiagram as an increase in thickness and density of the inner table of the skull, the earliest and most marked site being the inner table of the frontal bone. As it progresses, it gives the impression of obliteration of the already expanded diploe, by outward extension of the sclerosis. By inward extension, calcification of the attached border of the falx is early seen in stereoscopic skiagrams, and later diffuse extensive exostoses may be formed on the inner aspect of the frontal eminences.

Such apparent outward extension is clearly seen in Rowe and Mortimer's case (Fig 9-A), a male patient of 26, whose period of overgrowth had been from eight

reason that some of the skiagrams we show give the impression of a greater demineralization of the face than is actually the case



Figs 9 A (above) and 9-B (below). Type 1, dysplasia. Calvaria of Rowe and Mortimer's case and of Scriver and Bryan's case respectively

to sixteen years, and who ten years later was "apparently in a state of downward functional transition"

The extent to which exostoses on the inner table of the frontal bone may occur is shown in Figure 10. This is the skull cap of a characteristic Type 2 change.

Although the facial bones in such crania may be somewhat denser than in Type 1 crania, the sclerotic process seems to be limited to the brain-case, and to arise from bone laid down by the cranial endosteum. It may greatly thicken all the bones of the brain case, and even diminish the cranial capacity. The increased calvarial density demands, in skiagraphy, x-rays of considerably higher penetration, and it is for this

As in the first type, there is also an increase in cancellous bone throughout the skull, with hyperplasia of the mastoid and paranasal sinuses. This would appear to be the earlier change, coincident with active bone resorption, and it would appear that the later sclerotic change is associated with what may be called the "functional involution" of a once hyperactive anterior lobe. We have discussed the mechanism of production of the sclerosis, in the light of experimental work, in another publication (28a).

An excellent example of this second type is the skull of Cunningham's (26) case (Fig 11). The following points were noted by Thomson (18)



Fig 10 Typical Type 2 calvaria weighing 500 gm. *Note* The large frontal sinus on the right extends 20 mm upward above the line of the saw cut is 40 mm laterally and 10 mm in antero-posterior direction. The left sinus extends 12 mm above the line of section, and is 25 mm laterally. The right sinus extended far back in the orbital roof the upper plate of which is attached to the specimen and shows part of an ethmoidal bulla in the sinus.

"The subject was a male who died at 35 of diabetes. His height was 6 feet one-half inch. The bones of the skull were remarkably thick, the superciliary ridges were very pronounced and the frontal air sinuses of great extent.

The pituitary fossa had undergone great expansion from the hypertrophy of the pituitary body" (Cunningham)

Thomson also noted

"the disproportionate increase in the dimensions of the face, which was more elongated than broadened, the chief increase being in the height of the superior and inferior maxilla. There was prognathism, and, when viewed from above, the zygomata could be seen projecting on each side. The superciliary ridges, large and prominent, project beyond the glabella, and there was a deep depression at the fronto-nasal suture. The malar bones were prominent but there was no evidence of dilatation of the antra, described by Mr Broca as characteristic of acromegaly, and as the cause of the prominence of the cheeks during life."

The skull was abnormal for Scottish skulls in length, breadth, and height, and the cubic capacity was considerably over normal, as was the external circumference. He labelled the skull "megacephalic" (1890). He gives the nasion-symphysis measurement as 148 mm, against a normal of 124.5 mm derived from ten normal Scottish skulls.



Fig 11 (above) The Cunningham Thomson Skull, from the Museum of the Department of Anatomy Edinburgh University. Skiaogram by the courtesy of Dr Duncan White. Patient was male acromegalic aged 36 years.

Fig 12 (below) No 3 861-1 in the Royal College of Surgeons' Museum, London. Described by Sir Arthur Keith as the Nicolucci Skull (1911). A modern Roman male skull the subject of acromegalic changes age unknown.

There was extensive obliteration of the sagittal and lambdoidal sutures, all muscular ridges were prominent, particularly the median ridge of attachment of the ligamentum nuchæ, which was 6 mm in height.

The orbits were enlarged, especially transversely. The upper jaw was vertically elongated, especially between the orbit and the alveolar border, and the latter margin massive and spongy. The palate was elongated, narrow, and deeply concave, and in the middle line showed recent new bone, perforated like a sieve by vascular foramina.

The mandible was very large and massive, the body very deep, and inclined forward at the symphysis. The rami were more increased vertically than anteroposteriorly, and the angle measured 112.5 degrees. The coronoid process was about a third higher than normal, the condyles were greatly increased transversely.

The cut surface of the calvaria revealed the thickness of the bones to vary from 6 to 12 mm (note that this was not measured at the vertex) and both tables could be distinguished with intervening diploe, increased in thickness and density. Where the cut opened into the frontal sinuses, these were found dilated, the left measuring 45 mm vertically and 35 mm transversely, with the bone over them thick and massive, from bony deposition.

The sella turcica was enlarged, 22.5 mm anteroposteriorly, 21 mm transversely, and 18 mm deep. The posterior clinoids were pushed backward and as thin as paper. The fossa was deepened at the expense of the sphenoid, which was only a quarter of its normal thickness vertically, its sinus was not enlarged.

The groove for the middle meningeal artery was deep and broad. Finally, he notes the diminution in size of the anterior fossa of the skull, by encroachment of the frontal sinuses and elevation of the orbital plates.

In concluding, he stressed the absence of dilatation of the mastoid, sphenoid, and maxillary sinuses in this specimen, in reference to Broca's pathological report on Marie's case, and sought to account for this difference by the sex and age of the patient. He failed, however, to note that, while his own specimen was sclerosed, Marie's case showed such marked decal-

cification that the os calcis "pitted with the finger"—it was a pure Type 1.

The skiagram of this specimen (Fig 11) demonstrates clearly the calvarial thickening and increase of density, despite which the three tables can just be made out, with the great increase in relative thickness of the diploe, which is secondarily sclerosed. Although the frontal part is slightly more affected than the rest of the calvaria, the whole vault is much more uniform in thickness than is normally the case. There has been definite addition of bone at the external occipital protuberance. The frontal sinuses are large and extend into the orbital roofs, for about half their extent, but the detail here is somewhat confused by the presence of the wiring keeping the skull-cap in place. This latter provides a good objective standard of comparison of density for the structure of the calvaria.

The mastoid cells are large and numerous, a fact that can be made out despite the density of the overlying bone. The expansion of the sella turcica is clear, but the degree of development of the sphenoidal sinus cannot be made out, owing to the superimposed density of the sclerosed bone of the floor of the middle fossa. This sclerosis extends to the petrous pyramid.

The antra are not expanded, and the overgrowth of the alveolar bone of the upper jaw in front, with its inclination forward, is well seen. The face is not prognathic, the mandible does not overshoot the upper jaw.

The second skull in this group is No 3,861-1, in the Museum of the Royal College of Surgeons, London, in which Type 2 changes are present in extreme form.

This skull is described by Keith (21) as the Nicolucci Skull, some of the significant measurements of which he gives: cribriform plate to glabella, 24 mm (normal, 14 mm), nasion to maxillary alveolar margin, 90 mm (normal, 70 mm), inter-zygomatic diameter, 154 mm (normal, 130 mm), calvarial thickness, in frontal region 15 mm, in parietal 15 mm. The

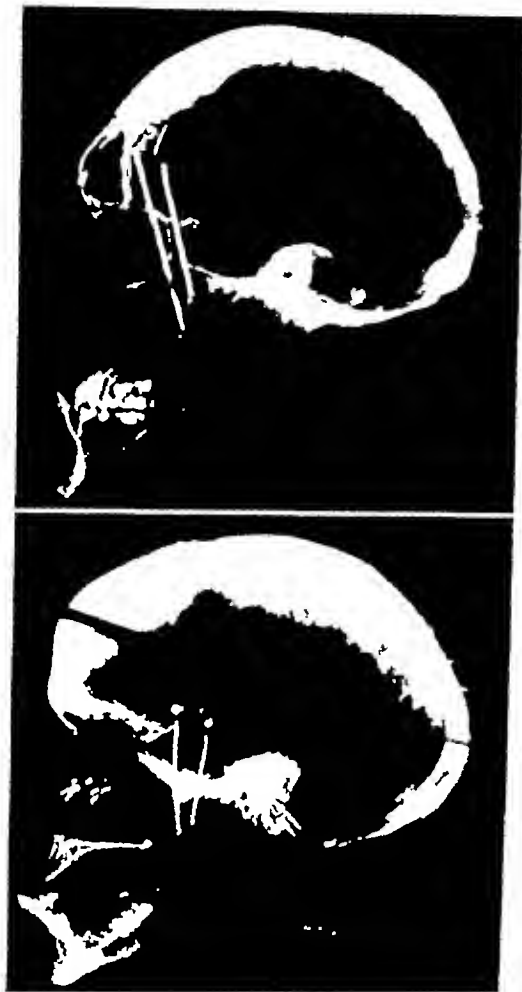


Fig 13 (above) No 1784 in the Warren Museum Harvard Medical School Presented by Dr Harvey Cushing Skull of male acromegalic aged 40 (chromophilic adenoma) Disease lasted 27 years Note the great thickening and increased density in the frontal region of the calvaria Skull-cap weighed circa 500 grams the whole skull (dried) 1 048 grams Compare with Figure 6

Fig 14 (below) Nos 3 802-1 and 3,802-2 in the Museum of the Royal College of Surgeons London Presented in 1911 by J Thomson Walker and described by Keith (1911) as the Thomson-Walker Skull Skull and calvaria of female about 40 years of age, showing atypical acromegalic features

Museum Catalogue gives the following facts

"A modern Roman skull (male) The skull is unusually massive in consequence of a diffuse thickening involving the frontal, the parietal, and all the bones entering into the formation of the roof and sides of the cranial cavity The thickened bones are dense and, for the most part, unnaturally porous, superficially,

and slightly roughened, the surface changes being less marked over the area corresponding with the origin of the temporal muscles Although the circumference of the skull is 570 mm, its capacity is but 1,500 c c The parietal bones, where thickest, $\frac{1}{12}$, in the neighborhood of the interparietal suture, measure 20 mm, and in section are closely cancellous, or compact without distinction of tables or diploe The pituitary fossa is considerably enlarged, proving the existence of pituitary disease The posterior part of the sagittal suture is obliterated

"The lower jaw is markedly enlarged, but without such thickening as could be called massive The length of the vertical ramus is increased, the chin pointed and unusually prominent The general enlargement, however, is evident in the divergence of the posterior margins of the vertical ram, and in the increase in the lower dental arch, which everywhere exceeds the upper "

In the skiagram (Fig 12), the enormously increased thickness and density of the calvaria are obvious, with complete loss of all architectural structure The confining of this sclerotic change to the brain-case is striking Along the vertex the superficial porous bone is seen as a somewhat striated or woolly outline, recalling somewhat the appearances in Paget's disease

The mastoid cells are large and numerous, the sella turcica is markedly expanded, and the frontal sinuses are abnormally large, extending about half-way into the orbital roof The sphenoidal sinuses cannot be made out clearly, but the maxillary antra, although well pneumatized, are not abnormally large

The mandible is not heavy, although, like the whole face, it is considerably over-penetrated by an exposure which was intended to show up the architectural structure of the calvaria There are two or three large medullary spaces in the prominent mental process The angle of the jaw is opened out and there is prognathism

The third Type 2 skull (Fig 13) is specimen No 1,784 in the Warren Museum, Harvard Medical School, presented by Dr Harvey Cushing (24) It is the skull of Mr Van W, an acromegalic who died

at the age of 40, when his height was 6 ft 6 in and his weight 269 pounds. Vigorous growth began at 13 years and at 19 he was 6 ft 4 in, weighing 200 pounds. At that age he was powerful, intelligent, and with uncontrolled libido. At 32 he was weak, drowsy and impotent, and had glucosuria. In the next three years he increased in weight and became practically blind. The glucose threshold was 300 gm. The tumor was a chromophilic adenoma.

Apart from the huge frontal sinuses, the increase in length of the face, the prognathism and the local destruction in the middle fossa of the skull, the outstanding feature in this specimen is the great calvarial thickening, with marked increase in density, which most affects the frontal bone and results in such a degree of sclerosis that the skull cap alone weighs close on 500 gm, while the whole skull weighs 1,048 gm.

In this respect it is interesting to compare this skull with the other specimen from the same source shown in Figure 6 (Warren Museum, No 61). Both were cases of chromophilic pituitary adenoma. The general facial deformity is very similar. In No 61 the frontal sinuses are large, but not huge as in No 1,784. It is, however, in the calvaria that the striking difference between the two crania is seen. In the former, the frontal bone is thin, the diploe being poorly developed and somewhat sclerosed, the skull cap weighing 215 gm and the whole skull 485 gm, while in the latter the frontal bone diploe had undergone considerable early expansion, followed by such marked sclerosis that the skull cap weighs as much as the other skull complete.

It is clear, that, whatever the clinical and histological similarities in the two cases may have been, there must have existed, probably over a long period of time, a marked difference in the calcium metabolism, as shown by the calcium reserve in the bones—a difference, as far as the skull is concerned, most evident in the frontal component of the calvaria.

Type 3—Of the eleven acromegalic crania there remains one which cannot be classified with either of the two foregoing types. It is specimen Nos 3,862-1 and 3,862-2 (the calvaria) in the Museum of the Royal College of Surgeons, London presented in 1911 by J Thomson Walker and described by Keith (21) as the Thomson-Walker skull. The following details are from Keith's paper and the Museum Catalogue.

"The skull and calvaria of a woman, supposed to have been about forty years of age, who died in Vienna, the clinical history being unknown. The specimen shows marked enlargement of the pituitary fossa, with atypical acromegalic features. Anteroposteriorly the sella measures 19 mm, 22 mm in width, and 14 mm in depth. From cribriform plate to glabella is only 15 mm (normal 14 mm). From nasion to maxillary alveolar margin is 71 mm (normal 70 mm), the inter-zygomatic distance is 124 mm (normal 130 mm), and the cranial capacity is only 1,200 c c (normal 1,540 c c for adult male). The frontal and parietal bones are thickened and sclerosed, but there is an absence of any pronounced supra-orbital ridges, and the upper part of the forehead is not unduly shelving. The frontal sinuses are small. The palate is increased in area, and there is an increase in height in the alveolar process of the lower jaw, accompanied by some change at the angle, and increased height of the ramus. There is but little elongation of the face, or increase in mental prominence. The muscular depressions on the base of the skull are exaggerated. Where the frontal bone is thickest it measures 15 mm."

The lateral skiagram (Fig 14) shows a small skull whose facial part is not large in proportion to the small brain-case, in fact, the upper part of the face, if anything, seems small in comparison. The frontal sinuses are hypoplastic, having reached only the size of those of a girl of about ten years. The damage to the sella is obvious, the antra are not expanded, and the maxillary alveolar process projects forward to a moderate degree. The mandible is moderately prognathic.

The striking feature in this case is the thickening and great increase in density of the calvaria. This most affects the frontal and parietal parts, the occipital part much

less The brow has almost the vertical slope of childhood, a fact that is in accord with the almost infantile frontal sinuses, another fact that is very surprising in an acromegalic cranium. An impression of the great density of the bone, which seems to have occurred as an internal deposit and may account in part for the small cranial capacity, can be got by noting that it is almost equal to the density of the metal rods supporting the specimen.

At first we were rather nonplussed by the marked lack of certain of the outstanding features of the other acromegalic crania in this series, such as marked enlargement of frontal sinuses and increase in length of the face. Despite the evidence of damage to the sella turcica and the mandibular changes, the possibility arose, in the absence of a clinical history, of there being an element of Paget's disease present. Accordingly, we were very doubtful of the possible value of this specimen as a guide to the recognition of pituitary influence, in the lesser degrees of change in cranial form and structure. Contrary to our expectations, however, this specimen has proved to be of the greatest importance, although it was not until we had examined many hundred cranial skiagrams that we began to appreciate it.

In the light of 71 cases in our series, which showed changes similar in nature but less in degree, the great majority of which were women showing adiposity as well as other symptoms of pituitary failure in the later stages, we have little hesitation in concluding that such a cranium is produced by a dyspituitarism, in which the hyperfunctional phase is slight, transitory or non-existent and the hypofunctional phase is the long-lasting and dominant characteristic.

In this case we are inclined to think it probable that, in the second decade of life, the patient suffered from a pituitary hypofunction from which resulted the frontal sinus hypoplasia, and the onset of a calvarial sclerosis.

In cases in which small frontal sinuses are found in association with a thickened,

dense calvaria, as in this case of the Thomson-Walker skull, we are inclined to think that this condition is due, not to the obliteration of sinuses that were once larger by the process of sclerosis, but to the fact that a condition of hypopituitarism was present during the years of active growth of the sinus, and that the part of the frontal bone, into which the sinus ordinarily would have extended, was similarly affected.

In the 500 dysplastic skulls in our series, we have seen no evidence of a frontal sinus, once formed, becoming secondarily obliterated, or even diminished in size, although the reverse process does occur, i.e., a frontal sinus may become larger after the attainment of its full adult size, if a condition of active hyperpituitarism be present.

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(To be concluded)

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with subsequent calcification taking place in the ligament (2) Others (9) are of the opinion that a fracture of the internal con-

there was no need for periosteal participation in the formation of the mass

The tibial collateral ligament seems to be

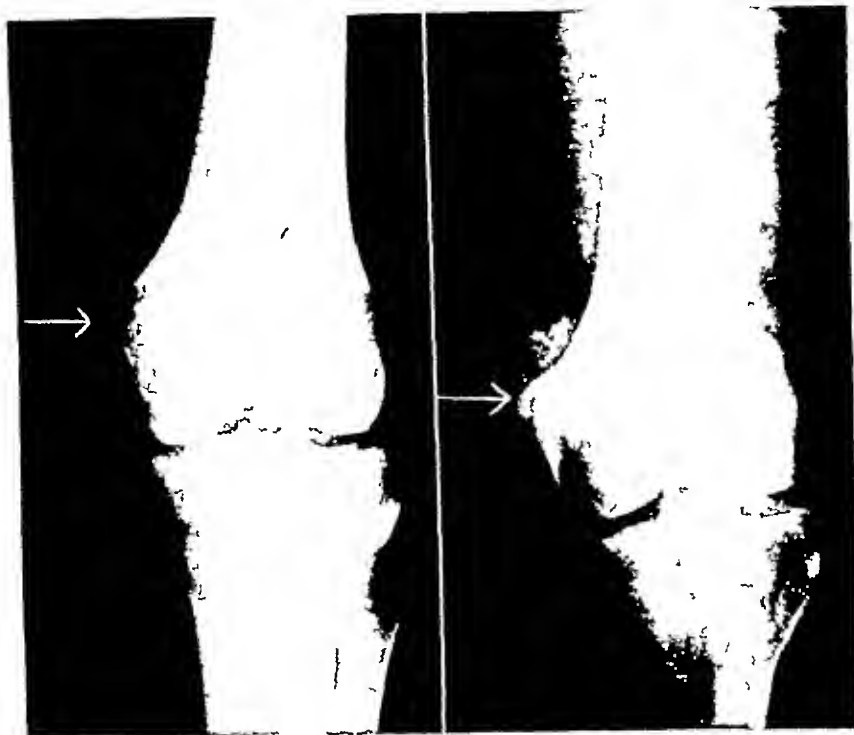


Fig 1

Fig 2

Fig 1 Early manifestation of Pellegrini-Stieda's disease 20 days after injury in a 50-year old white male A faint, semilunar-shaped shadow can be seen near the internal condyle of the left femur

Fig 2 Pellegrini Stieda's disease in a 55-year-old white female in whom roentgenograms immediately after first injury to the left knee (July 1933) showed no para articular deposit The above roentgenogram, made 20 days after second injury (3½ years after first), shows a deposit near the internal condyle of femur the density of which suggests it to be the result of the initial and not of the recent injury

dyle of the femur might or might not be present and that ossification is due to metaplasia of connective tissue König, Köhler, Pfister, and Ewald were definitely of the opinion that calcification seen in the ligament was a fractureless callous formation, and that it was the end-result of periosteal proliferation secondary to a tear in the ligament and tendons at that point as shown by the fact that the process never appeared within from two to three weeks after injury (3) Kulowski (5) believed that the clear space between the bony mass and the femoral margin demonstrated

most frequently affected (6), but different structures of the knee may be involved as was shown in Kulowski's patient in whom at operation the tibial collateral ligament was found to be free from pathologic changes which affected the adductor magnus and vastus medialis tendons (5) Andreesen (7) believed that calcification occurred in the attachment of the adductor magnus tendon So opinions have differed concerning not only the site of involvement, but also the type of pathologic change produced in Pellegrini-Stieda's disease These differences of opinion are not serious ones,

PELLEGRINI-STIEDA'S DISEASE

A MANIFESTATION IN THE KNEE OF POST-TRAUMATIC CHANGES COMMON
TO OTHER JOINTS¹

By H S CALLEN, M D, *Bradford, Pa*

INTRODUCTION

PELLEGRINI-STIEDA'S disease is a post-traumatic disorder of the knee in which roentgen opacities appear near the internal condyle of the femur, but do not, as a rule, become manifest until two to three weeks after injury to the knee (1). Because each of the terms *calcification* and *ossification* have been applied to such roentgen opacities, confusion has arisen pertaining to which represents the true pathologic condition of this disorder. The exactitude of Pellegrini-Stieda's disease, as a disease entity, has also suffered because of conflicting reports pertaining to the structures of the knee it affects, and because similar changes occur about other joints after trauma.

Explanations will be proffered as to why para-articular calcification or ossification may occur after trauma, and a theory advanced pertaining to why certain joint structures seem more prone than others to become the seat of such pathologic processes. To indicate that Pellegrini-Stieda's disease is but a local manifestation of post-traumatic changes common to joints, attention will be called to points in common between it and other disorders in which para-articular deposits occur after trauma and form roentgen opacities about the involved joint.

PELLEGRINI-STIEDA'S DISEASE

Pellegrini, in 1905, first called attention to ossification of the tibial collateral ligament, and Kohler in the same year reported a similar case. Stieda, unaware of the previous work of Kohler and Pellegrini, drew attention in 1907 to a semi-

lunar-shaped calcification seen about the superior border of the internal condyle of the femur (1). Thereafter numerous reports of so-called Pellegrini-Stieda's disease appeared in European medical literature, but no mention of the condition was made in our literature until July, 1932, when an editorial pertaining to it appeared in the then current issue of the "The American Journal of Roentgenology and Radium Therapy" (4). In 1933, Kulowski (5) was the first, in the English medical literature, to report a case of Pellegrini-Stieda's disease, since when 54 instances (4, 6, 9) of calcification or ossification near the internal condyle of the femur have been reported as having been observed in our United States.

Surely it has been the experience of others as well as myself to encounter additional cases of Pellegrini-Stieda's disease (Figs 1, 2, 3), since our attention has been directed to the possibility of such a condition developing in the knee after trauma. Failure to have recognized this disorder more frequently is believed due to delayed roentgenographic appearance of the lesion (4).

Like other traumatic disorders, Pellegrini-Stieda's disease has a higher incidence in males (6), and resurrection, as it were, of this condition invites our serious attention to it and to analogous disorders because of possible medico-legal implications.

Pellegrini was under the impression that ossification followed trauma. Most observers are agreed that in this disorder ossification does follow trauma and that the injury may be direct or indirect in nature. Stieda attributed the condition to fracture with detachment of a small particle of bone at the moment of injury.

¹ Read at the Twenty second Annual Meeting of the Pennsylvania Radiological Society, Erie, Pa. May 21-22, 1937.



Fig 5

Fig 5 Myositis ossificans. Bone laid down presumably in capsule of joint. No history of injury (Illustration reproduced from 'Diagnostic Roentgenology,' Thomas Nelson & Sons, New York 1936, Fig 125, p 361)

Fig 6

Fig 6 Para-articular ossifications in the knee of a tabetic (Illustration reproduced from 'Diagnostic Roentgenology' Thomas Nelson & Sons New York, 1936, Fig 130, p 473)

to disappear spontaneously or to disappear after the institution of physical therapy, while in other instances such deposits persist in spite of medical forms of treatment (1, 4, 6, 9, 11)

MYOSITIS OSSIFICANS

Kulowski (5) likened the bony mass found in his case of Pellegrini-Stieda's disease to that occurring in myositis ossificans. While myositis ossificans is not strictly a para-articular disorder, it occasionally occurs not far distant from joints, and sometimes after trauma. "Drill bone," common among enlisted men in the infantry, is a traumatic, circumscribed form of myositis ossificans occurring in the deltoid muscle of the shoulder. Myositis ossificans sometimes develops in the quadriceps femoris of football players after injury, and in the brachialis anticus after some posterior dislocations of the elbow, and is believed sometimes to affect joint capsules (Fig 5)

Myositis ossificans and Pellegrini-Stieda's disease have another point in common, in that recurrence of the pathologic process has been experienced after too early surgical intervention in either condition (5, 14)

PARA-ARTICULAR OSSIFICATIONS OF PARAPLEGIA

Ossifications have been found to occur about joints in some cases of paraplegia (Fig 6) in which trauma has been held responsible. There are some who believe that tabetics *per se* develop bone in soft tissue at the slightest traumatic provocation, such as the prick of a hypodermic needle. Osseous deposits, however, occur about joints of paraplegics who are not syphilitics, and it has been assumed by some that in such instances rough handling by ambulance or hospital attendants has been responsible for the development of these deposits, just as use of joints in tabetics prior to the preparalytic stage of



Fig 3 (above) Roentgenogram of right knee showing a proximal semilunar shaped shadow and a smaller distal shadow near the internal condyle of right femur (14 months after injury) in a 49-year-old white male in whom roentgenograms of the knee showed no evidence of this condition the day after injury

Fig 4 (below) Calcified subdeltoid bursitis in a 44-year old white female (No definite history of injury Used simply as an illustration of calcified subdeltoid bursitis)

specific nature of the disorder as a disease entity, and since, as will be discussed later, other joints sometimes become likewise affected after trauma, the only feature to distinguish Pellegrini-Stieda's disease is its gross anatomic location, the knee

SO-CALLED SUBDELTOID BURSTITIS

Lewin (8) believed that calcification or ossification of the tibial collateral ligament was analogous to calcification of the supraspinatus tendon in the region of the subdeltoid bursa (Fig 4). Until Codman (12), in 1906, clearly showed that the subacromial and the subdeltoid bursae were identical and their names synonymous confusion existed pertaining to structural involvement in so-called bursitis of the shoulder. In this disorder there still is confusion pertaining to structural involvement, for some investigators feel that the initial lesion is always in the supraspinatus tendon, while others state that trauma is to the bursa at the time of abduction movements, the bursa being injured as it glides beneath the acromion (11). In this discussion we are concerned only with post-traumatic deposits, which in subacromial bursitis are not always due to calcification as shown by Case (13). He discovered such a deposit to consist of both bone and cartilage.

Analyses of calcium deposits in the body have revealed them to consist of calcium phosphate, from 80 to 85 per cent, and calcium carbonate from 15 to 20 per cent, the approximate percentages in which calcium salts occur in bone (10). Such equality of percentages explains the similarity in roentgenographic density of calcifications and ossifications of similar size, and points out the hopelessness of roentgenographic differentiation between the two, in the absence of trabeculation, justifying the use of either of these terms until such time when deposits as these can be identified histologically, if necessary.

Like the deposits occurring in so-called subdeltoid bursitis those developing in Pellegrini-Stieda's disease have been known

being more or less of academic interest, but they nevertheless detract from the

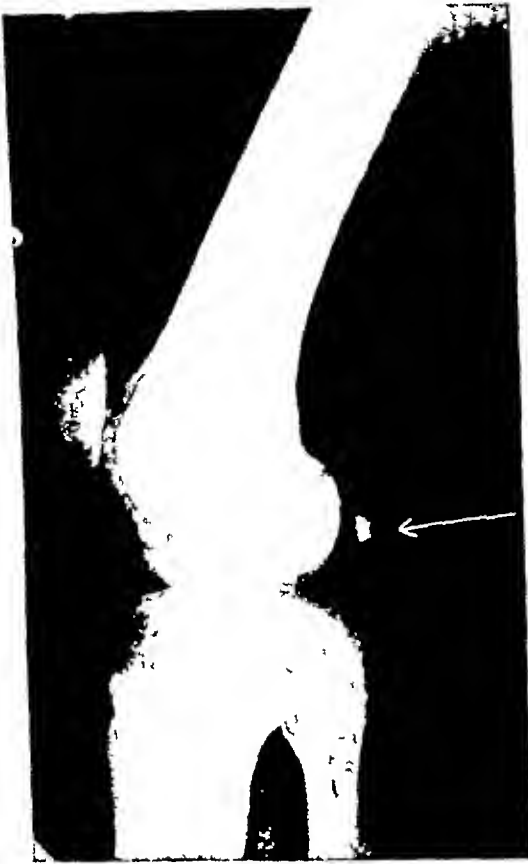


Fig 9 Lateral roentgenogram of an adult white male showing a fabella in the left knee presumably in the tendon of the gastrocnemius muscle

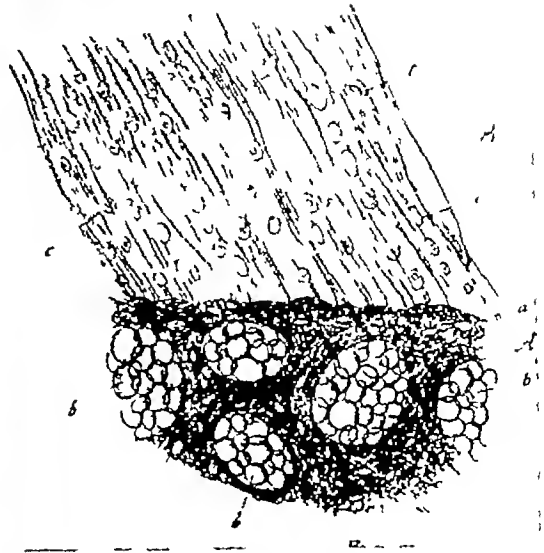


Fig 10 This drawing depicts cartilage cells (C) in the end of the Achilles' tendon (B) which attaches directly to the bone of the os calcis (A) (Illustration after Kollicker, and reproduced from Tumors of Bone, C F Geschickter and M M Copeland Revised Edition, Am Jour Cancer, 1938 Fig 23)

comes into contact with fatty acids derived from the pathologic process of fatty degeneration, insoluble soaps are formed giving rise to calcific deposits in the tissue affected (15). Ligaments and tendons then, because, of greater exposure to direct or to indirect trauma are, therefore, probably more prone to become the depositories of insoluble soaps, as the result of injury.

Ossification—Bone is the most highly differentiated of the connective tissues. It is not a primary, but a secondary tissue being preceded either by cartilage or by fibrous connective tissue. That developed from hyaline cartilage is called endochondral bone, while that formed from fibrous connective tissue without the intervention of cartilage is known as intramembranous bone (16). Freund (5) found the following different types of bone to com-

prise the osseous mass in a case of Pellegrini-Stieda's disease, bone formed on the basis of connective tissue, bone formation which was callus-like in character, and endochondral bone.

Because fibrous connective tissue possesses power to form a special type of bone, and because fibrous connective tissue is the principal constituent of ligaments and tendons, these structures are inherently capable of producing intramembranous bone when so provoked, as by trauma, for instance, but to conceive how endochondral bone can form in ligaments or tendons necessitates a brief consideration of the histogenesis of joints.

Not only intra-articular tissues, but ligaments, tendons, and bursæ nearest the joint are derived from precartilaginous, or blastemal, tissue capable of forming both cartilage and bone. Mesenchyme destined to form both cartilage and bone condenses (Fig 7) at the site of the future skeleton in the early embryo.

Strands of this tissue (Fig 8) cut their way across the future bone at right-angles to it and persist at the site of future joints.

their disease is thought to be the traumatic factor in such cases (10).

Paraplegia, then, regardless of its etiology, is another condition in which osseous deposits sometimes occur about joints after trauma

SITES OF PREDILECTION

Particular ligaments or tendons of certain joints seem more prone than others to undergo calcification or ossification after injury. This is probably due, in part at least, to greater exposure of the ligament or tendon in question to direct or to indirect trauma

PATHOLOGY

Some conditions have been stated in which calcific or osseous deposits develop about joints following trauma. Why calcification occurs in some and why ossification occurs in other instances, and why in still other cases neither of these pathologic changes develops after injury is at present inexplicable. Perhaps it will eventually be shown that trauma produces a local disturbance in tissue balance which, depending upon the prevailing state of glandular balance or the lack of it, results either in calcification or ossification in the latter, or in no pathologic change in the former instance. For the present it is pertinent that we pause for a moment to consider the manner in which calcification is believed by some to take place, and to review the different ways in which ossification occurs.

Calcification usually develops in tissues which are dead or in a state of reduced vitality as the result of some abnormal antecedent process, which as a rule is usually of an inflammatory nature. The conditions under which inflammation most frequently occurs are almost always associated with some form of injury. Fatty degeneration of cells frequently precedes calcification, and this might possibly account for the time interval elapsing between injury and the appearance of roentgen opacities. Calcium salts are obtained from the blood and lymph in which they

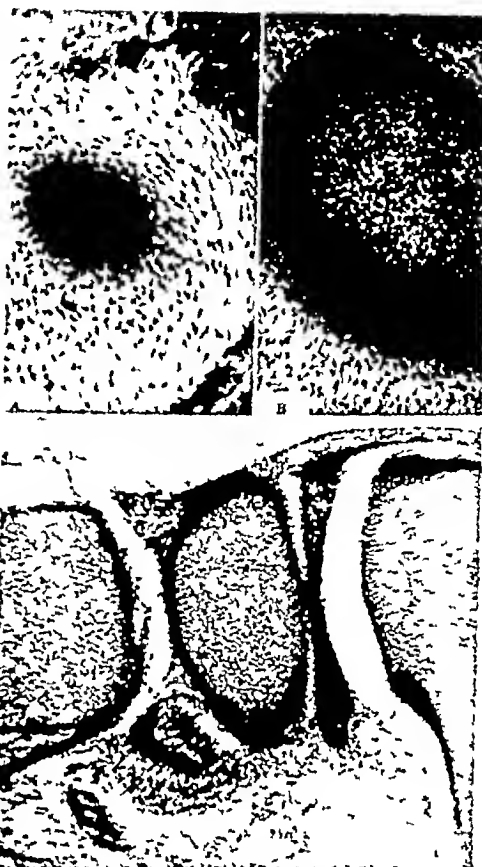


Fig 7 (above). Photomicrograph of human embryo tissue $\times 140$ mm. (A) shows the condensation of embryonic tissue (blastema) at the site of the future skeleton and in (B) this precartilaginous condensation of connective tissue is giving rise at its center to early cartilage cells. The persisting rim of dense connective tissue about the early cartilage cells is the primitive perichondrium and has the power to form both bone and cartilage. Persisting strands identical in nature with the perichondrium are referred to as precartilaginous connective tissue. (Illustration and legend reproduced from Tumors of Bone, C. F. Geschickter and M. M. Copeland, Revised Edition, Am. Jour. Cancer, 1936, Figs. 1-A and 1-B.)

Fig 8 (below). Photomicrograph of human embryo tissue $\times 140$ mm. Low magnification of the bones about the knee joint. The bones have been preformed in cartilage. About this cartilage the dense embryonic connective tissue which is the forerunner of cartilage persists. Note that this early connective tissue is present in the future joint cavity and also adherent at the places where the tendons are forming. (Illustration and legend reproduced from Tumors of Bone, C. F. Geschickter and M. M. Copeland, Revised Edition, Am. Jour. Cancer, 1936, Fig. 3.)

are ordinarily held in solution. One theory propounds that when such solution

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Fig 11 Lateral view of left ankle of a 47 year-old male showing recent fracture of ossified tendo Achilles, ossification presumably having taken place after initial injury 15 years prior to recent injury which fractured the ossified tendon (Illustration from "Radiography and Clinical Photography" D M Clark, December, 1936, 12, 11)

By mucoid regression some of this tissue forms joint cavity, the surrounding condensation of mesenchyme forming synovial membrane. Other strands persist at the reflection of the joint capsule and at its points of attachment to tendons and ligaments (14). So it is in this manner that ligaments, and tendons come to acquire inclusions of primitive tissue which evidently lie dormant in the sense of Cohnheim cell rests until stimulated, as by trauma, to undergo metaplasia. A sesamoid bone of the knee, the fabella (Fig 9) is an example of endochondral bone arising from a primitive tissue inclusion in the gastrocnemius tendon. Kollicker (14), as early as 1853, depicted cartilage cells in the Achilles' tendon (Fig 10), a location in which extra-skeletal ossification occasionally occurs (Fig 11).

SUMMARY

1 Because confusion has arisen pertaining to which of the terms, *calcification* or *ossification*, represents the true pathologic condition occurring in Pellegrini-Stieda's disease, it has been pointed out that either calcific or osseous processes may develop about joints after trauma.

2 Attention has been called to the hopelessness of roentgenographic differentiation between calcific and osseous deposits of similar size in the absence of definite trabeculation, justifying the use of either of the terms *calcification* or *ossification* in reference to roentgen opaque deposits of such character.

3 Fatty degeneration, a pathologic process thought by some to precede calcification is suggested as a possible cause for the delay in the roentgenographic appearance of calcific deposits developing after injury.

4 The extra-skeletal formation of endochondral and of intramembranous bone has been briefly reviewed.

5 A theory has been advanced pertaining to why particular ligaments or tendons of certain joints seem more prone than ligaments or tendons of the same or of other joints, to become seats of ossification or calcification after trauma.

6 Analogies have been drawn between Pellegrini-Stieda's disease and some other disorders in which, after trauma, para-articular calcification or ossification sometimes develops, indicating that the former condition is not truly a disease entity, but a local manifestation in the knee of post-traumatic changes common to other joints.

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Fig 2

However, there is never any ankylosis at birth or in intra-uterine life. The roentgenograms of the newborn show the middle phalanges to be in very close approximation to the proximal phalanges. Anatomic and histologic examinations reveal a hypoplasia and sometimes an aplasia of the joint structure. Usually it is symmetrical joints which are involved.

Cunningham describes the formation of the normal joint as follows:

The primitive immovable joint is first recognized as a mass of undifferentiated mesodermic cells situated between the two masses,



Fig 2 A

which have differentiated into primitive cartilage.

"The cell mass which constitutes the joint-unit presents the appearance of a thick cellular disc, the proximal and distal surfaces of which are in accurate apposition with the primitive cartilages, while its circumference is defined from the surrounding mesoderm by a somewhat closer aggregation of the cells of which the disc is composed. From this cellular disc or joint-unit all the structures characteristic of amphiarthrodial and diarthrodial joints are ultimately developed.

"Within the substance of the disc itself a transverse cleft, more or less well-defined and complete, makes its appearance. In this manner the disc is divided into proximal and distal segments, separated from each other by an interval which is the primitive articular cavity. This cleft, however, never extends so far as to interrupt the continuity of the circumferential part of the disc which develops into the fibrous tissue of the investing ligaments. From the proximal and distal segments of the articular disc the various structures, distinctive of movable joints are developed."

Duken (6) who made the pathologic and anatomic investigation of this condition, came to the conclusion that the stiffness is due to the hypoplasia and sometimes anaplasia of the interphalangeal joint and these anomalies are produced as a result of insufficient and irregular differentiation of the intermediary zone of the pre-cartilage tissue. These changes in the joints result in varying degrees of bony ankylosis.

Ankylosis starts in childhood and early youth, becoming more marked as the subject grows older. At any one time various stages of ankylosis can be seen in various joints. (See Fig 1.) Observers have been able to follow up all the stages to complete and solid bony union. Sometimes in

HEREDITARY MULTIPLE ANKYLOSING ARTHROPATHY¹

(CONGENITAL STIFFNESS OF THE FINGER JOINTS)

By A R BLOOM, M D *Detroit, Mich*

From the Roentgen Department of the North End Clinic

HEREDITARY multiple ankylosing arthropathy is a rare hereditary condition in which there is ankylosis of the middle and proximal phalanges of the hands together with changes in other joints of the body, and it is due to a congenitally inherited abnormality of the cartilages between the joints. Genealogical investigation of the various cases reported in the literature proves that this anomaly is inherited according to Mendel's law. It is a

one family, they called it "congenital stiffness of the finger joints." They reviewed the literature which included reports by Rochline (4), Aschner (5), Duken (6), Drinkwater (1), and Kohler (7). Harvey Cushing (8) described this condition in 1916, in "Genetics" under the name of "hereditary ankylosis of the proximal phalangeal joints" (sympylalangism).

The term "congenital stiffness of the finger joints" seems to me to be misap-

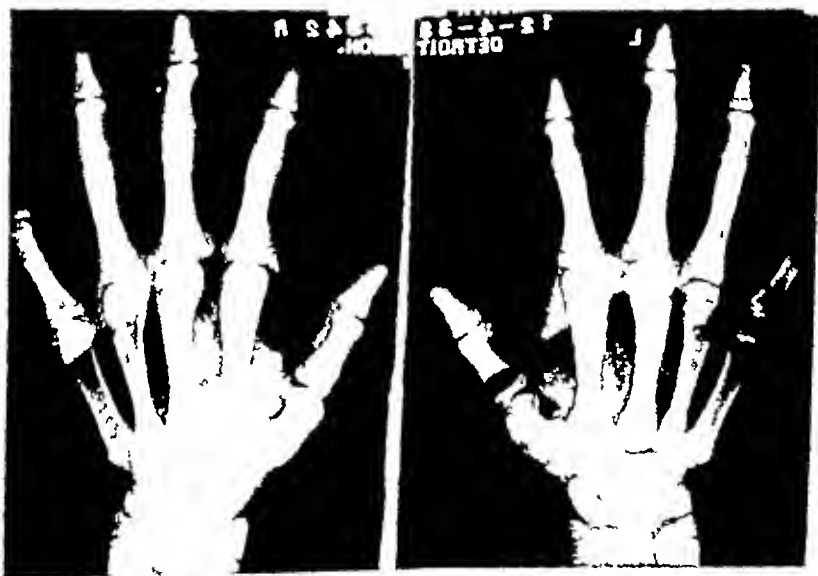


Fig 1

distinctly dominant characteristic and not sex-bound. Drinkwater (1) has traced the genealogical tree of one family with stiff fingers through fourteen generations, and Révész (2) reported a case which he traced in three generations.

In 1932, Rochline and Simonson (3) described two cases of this rare anomaly in

plied. It does not describe the condition accurately, for it is not limited to the finger joints, neither does "congenital stiffness" describe the cause nor convey the mechanism of the rigidity. I have suggested the term *hereditary multiple ankylosing arthropathy* as being more descriptive and informative.

The joint involvement is readily apparent at birth and such joints as are free of abnormality at that time never ankylose.

¹ Read by title at the Twenty second Annual Meeting of the Radiological Society of North America at Cincinnati, Nov 30-Dec. 4 1936



Fig 6 (two views)

pronated feet with prominent scaphoids. The feet were very rigid, and there was considerable peroneal spasm. There was tenderness along the longitudinal arches. The patient was referred to the Roentgen Department for radiographic examination of the feet, with a tentative diagnosis of spastic flat feet or calcaneonavicular coalition. After the report given below was made, the boy was given a more extensive examination. It was found that the digits of the hand tended to spread. The little finger was deformed at the distal joint and adducted. There was a disturbance in the joint line as though the radial side of the epiphysis did not keep up with the ulnar. Similar, though less marked, changes were noted in the fourth finger. (All changes were symmetrical.) There was a bulbous enlargement at the distal phalanx of the index finger. Apparently there was an absence of interphalangeal joints of the fourth finger of each hand (Fig 6). The patient was unable to close his fist. The elbow (Fig 8) showed an increase of the carrying angle, with limitation of supination. Further examination of the feet showed the heels to be inverted. The feet were broad, flat and rigid, with about ten degrees inversion. The toe joint was present (Fig 7).

On questioning the mother, we learned

that several of the boy's maternal relatives had similar deformities.

ROENTGEN FINDINGS

Anteroposterior and lateral views of both feet (Fig 2) show symmetrical changes. The arches are flat. Practically all the tarsal bones are fused into one solid mass, and very little, if any, demarcation of the individual bones can be seen. There is a separate bone between the base of the first metatarsal and the solidified tarsus, which I believe to be the cuneiform. The anterior aspect of the solid tarsus is straight and the posterior aspect of the cuneiform is in line with the bases of the second, third, and fourth metatarsals. The epiphyseal heads of the second, third, fourth, and fifth metatarsals are not united, and there are epiphyses present at the bases of the second, third, fourth, and fifth proximal phalanges. The third, fourth, and fifth toes have only two phalanges each. The second toes have three phalanges, the distal and middle being very small. There is an ununited epiphyseal plate at the base of the first distal phalanx. No epiphyseal plates can be seen between the distal and proximal phalanges of the other toes. The first metatarsal is shorter than the other metatarsals, although considerably broader. The combined length



Fig 1



Fig 4



Fig 5

older individuals the ankylosis has been so complete that no sign of the early division could be recognized (see Fig 2). At this stage there is a common bone marrow.

Although the condition is frequently termed "congenital stiffness of the finger joints," the fingers are never alone involved. All the cases reported have other joint abnormalities, but no case is without finger joint involvement. Four cases reported by Rochline and Sunonson (3) were as follows:

The first case had, in addition to changes in the finger joints, similar deformities of the head of the second to the fifth metatarsal, bilateral subluxation of the head of the radius, bilateral *cova vara*, flattening and increased transverse diameter of the twelfth dorsal, and all the lumbar vertebrae.

The second case had, in addition to the changes of the proximal phalanges, subluxation of the elbow joints and abnormalities of the metatarsals.

In another case there were changes of the facial bones, deformities of the thumbs and big toes, and ankylosis of all the phalanges of the feet.

In the case of an 18-year-old girl, the ankylosis of the finger joints was accompanied by changes in the soft tissue of the

fingers, giving a ring-like form of indentations.

Our case had, in addition to changes of the proximal phalanges, complete ankylosis of the tarsal bone of the foot (Fig 2), anterior subluxation and abnormalities of the heads of the radius (Fig 3), flattening and broadening of the sixth dorsal vertebra (Fig 4), wedging of the fifth, sixth, and seventh dorsal vertebrae, persistence of late epiphyseal plates, notching of the vertebrae (Fig 5), and abnormalities of the carpal bones (Fig 1).

The complete fusion of the tarsal bones of the foot has been reported before.

CASE REPORT

B. L., born in 1920, originally came to the North End Clinic in 1927 for ring worm infection of the scalp. In 1931 he was seen in the Pediatric Department because of enuresis. At that time he measured 59 1/4 inches and weighed 129 1/4 pounds. Because of his size and weight he was diagnosed as the pituitary type of endocrine disturbance, but x-ray examination of the skull revealed a normal sella turcica.

In 1933, he was referred to the Orthopedic Department because of painful feet of several years' duration. Examination by Dr. F. Fischer revealed very relaxed

fossa, but the head of the radius appears to be anterior to the humerus and interferes with complete flexion

Anteroposterior views of the dorsal spine (Fig 4) show the sixth dorsal vertebra to be rather flattened at the base. From the seventh dorsal to the base of the tenth dorsal vertebra, there is a fairly dense line about one eighth of an inch from either lateral aspect of the spine and parallel to the course of the spine. The ribs and the shoulder joint appear normal. Lateral view of the dorsal spine (Fig 5) shows a wedging of the fifth, sixth, and seventh dorsal vertebrae. There is marked notching of the anterior aspect of these vertebrae and the epiphyseal plates are quite prominent and separate.

CONCLUSION

(1) Another case of a rare hereditary condition is reported

(2) To the writer's knowledge, this is the

first case reported in which there is complete fusion of the tarsal bones

(3) The term *hereditary multiple ankylosing arthropathy* is suggested in the place of *congenital stiffness of the finger joints*

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Fig. 7



Fig. 8

of the first metatarsal and cuneiform is equal to the length of the other metatarsals

Anteroposterior views of both hands (Fig. 1) also shows symmetrical changes. There is a marked abnormality of the first metacarpal. It is broad and irregular in shape. The base of the second metacarpal is broad and notched. The neck of the first metacarpal is rather broad and tapers to the middle, resulting in a spindle-shaped appearance. The joint space between the metacarpals and the proximal phalanges appears normal. The epiphyseal heads have not united nor have the epiphyseal plates at the base of the proximal phalanges. The joint spaces between the proximal and middle phalanges of the second, third, and fourth fingers are very narrow and atrophic and in the fifth finger the two phalanges are united. One cannot see the point of union. There appears to be a united central cavity. The joint space between the proximal and middle phalanges of the first finger of the left hand shows beginning ankylosis, but the joint space can be made out. The joint space between the middle and proximal phalanges is straight across and very narrow, presenting the appearance of a fixed rather than a

movable joint. There appear to be six carpal bones present. There is one large bone which occupies the space of the capitate, lesser multiangular, and greater multiangular. This bone is triangular in shape and the base articulates with the first, second, third, and part of the fourth metacarpal. The hamate articulates with the fifth and part of the fourth metacarpal. The navicular is of normal size, but the lunate is rather small. The triquetrum is present but the pisiform cannot be made out. One bone about the size and shape of the pisiform lies below the bases of the fourth and fifth metacarpals. The distal epiphyses of the radius and the ulna are not united.

Anteroposterior and lateral views of the elbow (Fig. 3) show marked broadening of the condylar end of the humerus. The medial condyle is markedly enlarged and projects medially. There is evidence of an ununited epiphysis. The condyle on the radial side, by contrast, appears not completely developed, the head of the radius, instead of being flattened, is bulbular. The proximal epiphysis is not completely united. In the lateral view the trochlea of the humerus fits into the olecranon

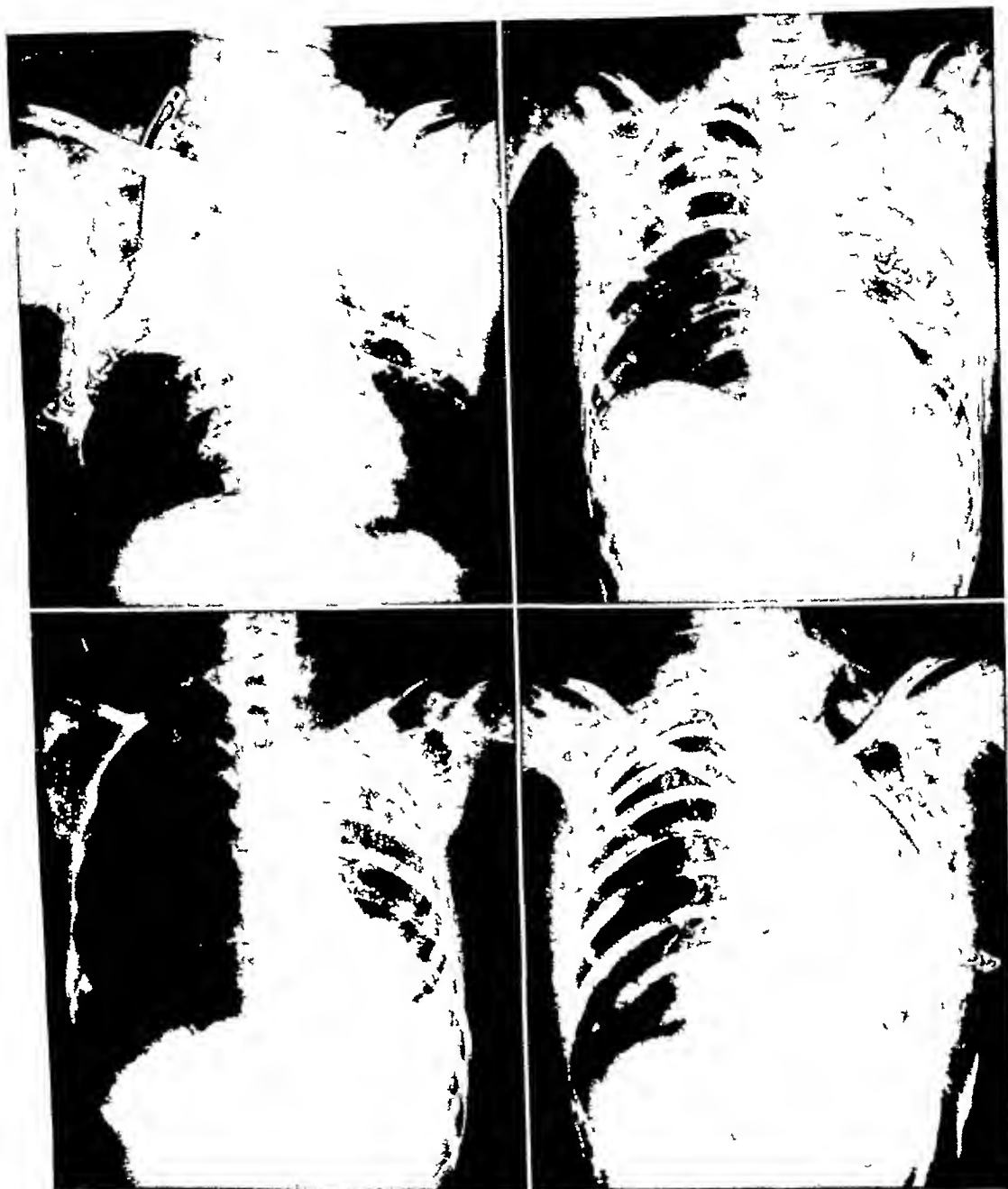


Fig 1 (upper left)¹
Fig 3 (lower left) Same case
as Fig 2

Fig 2 (upper right) Same
case as Fig 3
Fig 4 (lower right)

¹ It is suggested that the reproductions in this article be viewed through a reading glass in order to visualize detail structures etc

moved so as to free the underlying soft tissues from the non-yielding bony thorax, thereby permitting the greatest anatomical collapse of the lung. The underlying lung, following this procedure, collapses

down to the level of the third or fourth rib. Occasionally, the lung is adherent mesially, preventing this drop and thereby causing an inadequate collapse of the lung. In such instances, and in cases in which

CORRELATION OF SURGICAL AND ROENTGENOGRAPHIC FINDINGS FOLLOWING THORACOPLASTY FOR CHRONIC PULMONARY TUBERCULOSIS

By LEW A HOCHBERG, M D , C M , and LOUIS NATHANSON, M D , M Sc , Brooklyn, N Y

From the Surgical Service of Dr Pol N Coryllos and Roentgenological Service of Dr Henry K Taylor, Sea View Hospital

THORACOPLASTY has become a routine surgical procedure for the treatment of chronic pulmonary tuberculosis, in cases in which other less radical measures have failed to yield the desired results. The medical profession at large and particularly roentgenologists, thoracic surgeons, and phthisiologists are being called upon daily to interpret roentgenograms of patients in whom this has been performed. To properly interpret studies of this nature, the surgical procedure must be understood and the sequelæ resulting therefrom recognized.

In recent years, few papers have appeared dealing with the roentgenographic findings following thoracoplasty, and these describe individual phases rather than the subject as a whole. The vast material at Sea View Hospital permits a detailed study of this subject from both the surgical and roentgenological standpoints. In this communication we will attempt to correlate the surgical procedure and the roentgenographic changes seen following thoracoplasty in the examination of post-thoracoplasty roentgenograms.

FIRST STAGE

The surgical procedure in this stage consists of the subperiosteal resection of the upper three or four ribs, beginning as close to the vertebral margins as possible. The osseous portions of the first and second ribs are generally removed *en toto*, and only small anterior portions of the third and fourth ribs are left behind. Occasionally, portions of the transverse processes are removed with the costal structures.

Roentgenographic examination following the first stage reveals anterior portions of the third and sometimes fourth ribs with the complete absence of the first and second ribs (Figs 2, 6, 8, 12). The anterior

remnants of the third and fourth ribs appear drawn backward, and the entire upper thorax in the area of rib resection appears narrowed. At times, the transverse processes appear irregular and sectioned, characteristic of surgical removal. The underlying lung is retracted downward and inward and appears airless (atelectatic) with its apex usually at the level of the third or fourth interspace (Fig 6). Cavitation when visualized appears compressed and conforms to the general collapse of the lung (Figs 5, 6, 11, 13). The mediastinum may be displaced slightly to the contralateral side, but not appreciably, and similarly the diaphragm may be somewhat depressed. The trachea as a rule is shifted considerably to the opposite side, but does not undergo any change in the caliber of its lumen. There is a scoliosis of the upper dorsal vertebrae with a convexity toward the side operated upon (Figs 7, 8). Occasionally there is an anterior rotation of the lower cervical and upper dorsal vertebrae (Fig 7). This rotation is away from the side operated upon. The scapula and clavicle at this time appear prominent with no appreciable change in position (Fig 1). The immediate post-operative roentgenograms usually show considerable air scattered throughout the soft tissues of the area operated upon, extending into the neck and down the chest wall (Figs 1, 4, 12). About the operative site there frequently is a collection of air and fluid which may assume various configurations. This is more commonly seen above and lateral to the collapsed lung (Figs 1, 2, 8). Surgical dressings appear prominently on the roentgenogram and frequently a drain and skin clips may be seen *in situ* (Figs 1, 2, 4, 12).

At the time of the surgical intervention, relatively large segments of rib are re-



Fig 9 (*upper left*) Same case as Figs 10 and 17

Fig 11 (*lower left*) Same case as Figs 12 and 13

Fig 10 (*upper right*) Same case as Figs 9 and 17

Fig 12 (*lower right*) Same case as Figs 11 and 13

If, on the other hand, it is fixed, its deviation will conform to the displacement of the structure to which it is adherent. The maximum amount of shifting of the trachea is seen generally after the resection of the upper four ribs. The scapula and clavicle on the side operated upon become prom-

inent in this stage (Figs 3 and 4), but since neither depend on the ribs for support their position and alignment are not appreciably altered by the removal of the ribs. The sterno-clavicular joint on the opposite side appears broadened after the surgical procedure, the result of the rota-



Fig 5 (*upper left*) Same case
as Figs 6 and 21
Fig 7 (*lower left*) Same case
as Figs 19 and 20

Fig 6 (*upper right*) Same case
as Figs 5 and 21
Fig 8 (*lower right*)

the cavity pre-operatively was relatively large, the lung may be peeled away (decolated) from the surrounding structures, permitting a collapse similar to that of a non-adherent lung. If the lung is decolated farther, the collapse may be even greater than that obtained by the routine thoracoplasty. The mediastinum and diaphragm are not appreciably affected in this stage since there is relatively little

pressure exerted on these structures. The displacement of the trachea to the contralateral side depends on its previous position (Fig 1), its mobility (Fig 12), and the pressure exerted upon it by the collapsed lung (Fig 3). If, as a result of pulmonary fibrosis, the trachea is retracted to the affected side pre-operatively, then the collapse of the lung may tend to replace the trachea toward its normal position.

above the resection may show early regeneration. The lung at this time is depressed farther downward and mesially toward the hilus, and appears more atelectatic than in the previous stage (Figs 17, 20, 21). The cavity which was demonstrable before this stage, now appears further depressed and diminished in size (Figs 17, 20, 21). As in the case of the lung, the cavity is collapsed from above downward, and from without inward toward the hilus. The mediastinum generally shows a shifting to the opposite side (Figs 14, 18, 20). In left-sided cases particularly, one may also note a rotation of the heart and a change in the contour of the cardiac silhouette. The cusp of the diaphragm is often depressed a full interspace but retains its normal curvilinear appearance (Figs 14, 18, 20). The position of the trachea is not appreciably altered. The scapula stands out in relief and appears to be displaced farther laterally (Figs 14, 18, 20). This displacement is most marked when the arm is held in abduction. The clavicle can be visualized in its entirety from the sternum to the acromion. The sternoclavicular joint on the contralateral side shows no change beyond that seen after the first stage. The rotatory scoliosis is now more pronounced and involves a larger segment of the spinal column, frequently extending down to the area of rib resection (Fig 20). This rotation is again anterior and away from the side of the operation. There is a compensatory curvature in the lower dorsal and lumbar regions, with the concavity toward the operative side. The changes in the wound are similar to those occurring in the first stage. There may be more extensive subcutaneous emphysema and irregular collections of fluid at the site of the operation, and in the surrounding soft tissues. Again, a drainage tube and skin clips may be seen.

As noted above, the second stage is usually performed within three weeks after the first stage. If this stage is delayed further, rib regeneration usually takes place and the resulting collapse of the lung

by the routine second stage procedure is relatively inadequate. When new bone is visualized on the roentgenogram, it is too late for a simple second stage procedure. Generally, there is considerably more bone formation than the roentgenogram reveals. In cases in which there has been an unavoidable delay in the second stage procedure, the routine operation should be accompanied by a resection of parts or all of the regenerated ribs. If this delay has been over a long period, it is advisable to resect the regenerated ribs in one stage and at a subsequent date to do a routine second stage procedure. Since the angle of the scapula is at the level of the seventh rib, leaving that rib behind will cause pain as the scapula rides over it. The presence of the seventh rib permits the scapula to become adherent to it by fibrous or bony union, and thereby interferes with the movements of the scapula (Fig 20). If this occurs, resection of the bony attachment in the third stage may be difficult. The resection of the seventh rib in the second stage permits the scapula to fall in on the soft tissues and also aids the collapse of the lung (Fig 18).

As a result of the second stage procedure, the apex of the lung usually collapses down to the level of the fourth or fifth rib, with the greater amount of collapse of the lung and cavity from without inward (Fig 20). The volume of the lung collapsed in the second stage thoracoplasty is usually greater than that in the first stage. As noted in the first stage, further collapse of the lung may be obtained by decollating it from the surrounding adherent tissue.

Due to the mechanical pressure of the collapsed lung on the mediastinum, the latter is usually shifted considerably to the contralateral side (Figs 14, 18). In cases in which there has been a retraction of the lung and mediastinum to the affected side as a result of chronic pulmonary disease of long duration, the mediastinum will tend to return toward its normal position. In instances in which the mediastinum is not fixed nor retracted, the degree of shift to the contralateral side will de-



Fig. 13 Same case as Figs. 11 and 12

tory scoliosis and the anterior displacement of the sternum

As a result of surgical trauma and the formation of a dead space, air and fluid collect in the soft tissues between the large muscles of the posterior thorax and the extrapleural part of the collapsed lung (Fig. 8). This fluid is generally sero-sanguinous. The configuration of these collections may vary considerably depending upon the tissues in which they are confined. Air pockets in the wound proper may be confusing and simulate cavitation in the lung (Fig. 1). Only by knowing the previous exact location of cavitation is one able to differentiate between the overlying subcutaneous air pockets, air in the wound, a pre-operative residual pneumothorax, and cavitation in the lung (Figs. 9 and 10, 11 and 12). Frequently dense, sharply circumscribed shadows may be seen in the lateral superior part of the operative area. These shadows may show a fluid level and, therefore, are confused with encapsulated fluid in the pleural space. They are not infrequently diagnosed as localized hydropneumothoraces. At the subsequent operation, this fluid is found localized in the extrapleural

tissues and spaces. The overlying gauze dressings and adhesive strappings may also produce additional confusing shadows (Figs. 1, 4, 12), these, however, may be eliminated by the removal of the dressings before the roentgenogram is taken.

Roentgenograms made immediately after the surgical procedure should not be taken as the final result of the partial thoracoplasty (Figs. 12, 13). Changes occur subsequently both in the degree of compression and the degree of aeration of the underlying lung (Figs. 2, 3, 12, 13). Cavitation, which appeared almost completely obliterated in the immediate post-operative study, may become visible after the surrounding reaction has cleared up or the lung has partly re-expanded (Figs. 2, 3). The air in the overlying tissues is usually absorbed after several days, but the fluid in the wound may remain for an indefinite time, and require removal at the time of the subsequent procedure.

SECOND STAGE

Barring contra-indication such as an acute tuberculous spread, atelectasis, spontaneous pneumothorax, or advancement of a contralateral lesion, etc., the second stage is usually performed within three weeks after the first stage. This allows the patient ample time to recuperate from the initial procedure and is early enough to permit intervention before rib regeneration takes place.

In the second stage, the ribs are resected subperiosteally down to and preferably including the seventh rib. Large segments of ribs are resected, beginning as close to the vertebral border as possible and extending well beyond the anterior axillary line. With the vertebral resection of the ribs, occasionally part of the transverse processes are removed.

Roentgenographic studies following the second stage show rough anterior segments of the fourth, fifth, sixth, and seventh resected ribs with the costochondral junction undisturbed (Figs. 14, 18, 20). The transverse processes may or may not be present. The costal structure in the area



Fig 18 (*upper left*)
Fig 20 (*lower left*) Same case
as Figs 7 and 19

Fig 19 (*upper right*) Same case
as Figs 7 and 20
Fig 21 (*lower right*) Same case
as Figs 5 and 6

vious stage, roentgenograms taken immediately after the operation should not be considered as the final result of thoracoplasty (Figs 15 and 16, 19 and 20). Studies made some time after the procedure may show considerable re-aeration of the previously atelectatic lung (Figs 16, 20). Apparently the lack of visualization of the

underlying lung immediately after the surgical procedure is in part due to the reactionary changes in the operative field. With the re-expansion of the lung and absorption of the surrounding reactionary fluid and air, cavitation not previously visualized may become evident. As the lung expands laterally and upward, the



Fig 14 (*upper left*)
Fig 16 (*lower left*) Same case
as Fig 15

Fig 15 (*upper right*) Same case
as Fig 16
Fig 17 (*lower right*) Same case
as Figs 9 and 10

pend entirely upon the mechanical pressure exerted by the collapsed lung. The rotation of the heart, particularly in cases in which the thoracoplasty has been left-sided, may be so great that it produces cardiac embarrassment. When on the right side considerable embarrassment of the right auricle and superior vena cava

may result. The increased pressure exerted within the hemithorax causes the diaphragm to become depressed immediately after the operation. However, this is a temporary state and the diaphragm may later rise to its relatively normal position. At no time is there any impairment of diaphragmatic function. As in the pre-



Fig 23 Same case as Fig 24



Fig 24 Same case as Fig 23

be resorted to before one can visualize the underlying lung

THIRD STAGE

The question of whether or not a third stage should be performed depends on the original size of the cavity, its position before thoracoplasty was begun, the persistence of a positive sputum after the second stage, and whether or not there are other contra-indications such as those mentioned in the introduction to the second stage. If a third stage is contemplated, namely, the removal of ribs down to and including the tenth or eleventh, it should be performed before rib regeneration becomes a definite handicap to the collapse of the lung. If the delay is longer it requires the removal of regenerated ribs, which is difficult and not without danger. The ribs in this stage are again removed subperiosteally, as in the first and second stage, leaving the costochondral junction undisturbed and the anterior portions of the ribs in place.

On the roentgenogram, there is evidence of removal of the lower costal structures with the anterior portions of the ribs re-

maining *in situ* (Figs 23, 26). As a rule, these remaining stumps are longer than those in the first and second stages. The transverse processes in the lower cervical and upper dorsal regions being longer than those in the lower dorsal region, gives one the impression that longer posterior costal segments have been left behind in the upper dorsal regions than in the lower, although the ribs throughout were resected as close to the vertebral articulations as possible. The lung appears to be collapsed laterally. In cases in which a cavity was visualized pre operatively, the compression appears laterally, corresponding to the collapse of the surrounding lung tissue (Figs 23, 24, 27). The mediastinum is generally shifted considerably to the opposite side (Figs 26, 27). The trachea in this stage is not affected by the collapse of the lung except where it is the result of general displacement of the mediastinum (Figs 26, 27). The diaphragm appears markedly depressed and flattened with its sides standing almost in the erect position (Figs 26, 27). There is a more pronounced curvature and rotation of the dorsal spine with compensatory changes



Fig. 22

mediastinum may be retracted back to the operative side. At the same time, the diaphragm begins to return toward its previous position. As a rule, the lung tissue below the level of the operative field shows no remarkable changes immediately after the operation, but subsequently undergoes emphysematous changes if a third stage is not performed (Fig 18). The maximum change in the position of the trachea takes place with the resection of the upper four ribs and, therefore, following the first stage. Any further displacement which may take place corresponds to the subsequent mediastinal displacement. No further appreciable pressure is exerted directly on the trachea since the ribs in the first stage were removed down to the level of the cornea.

In this stage, with the removal of more ribs, the scapula and clavicle become more prominent and appear further displaced laterally. This change is only an apparent one since actual measurements from fixed bony points to the outer margins of the scapula and clavicle show no appreciable changes. In fact, during the surgical procedure, resuture of the muscles attached to the mesial border of the scap-

ula, brings it back to its relatively normal position. The clavicle and its bony attachments are not disturbed during the surgical procedure. Any changes in position of the clavicle are not due to the operation *per se* but, rather, to changes which have taken place in the structures surrounding the shoulder girdle, as a result of the operation. As in the first stage, the clavicle remains essentially unchanged. Occasionally, however, the clavicle appears elevated or depressed. This is due to the loss of muscular support and loss of antagonistic action of the muscles about the shoulder. The accompanying convex scoliosis and rotation of the spine help rotate the scapula and clavicle anteriorly. With the relaxation of the muscles about the shoulder girdle, the scapula and clavicle may become somewhat elevated or depressed, depending upon which group of muscles remains most unopposed or retracted. The sternoclavicular joint shows no change from that of the first stage. The visualization of this joint is also due to the rotatory scoliosis of the dorsal and cervical spine.

The rotatory scoliosis is more marked at this time, due to the further loss of support by the costal structures and imbalance of the muscular action (Figs 20, 22). Rotatory scoliosis is the result of the removal of ribs along one side of the spinal column and the unopposed costal pressure on the other side. It is most marked in young subjects in whom the spine is more pliable. It is not infrequently seen in individuals of poor muscular development.

Changes in the wound and surrounding soft tissues are similar to those in the first stage. The air and fluid may again produce confusing shadows. At this time, they occupy a larger area than in the first stage (Fig 15). The air pockets are most pronounced after the surgical procedure. Frequently, the air and fluid may not be absorbed for a considerable length of time, rendering the interpretation of the underlying pulmonary pathology difficult—in fact, almost impossible (Fig 18). Not infrequently aspiration of the fluid must

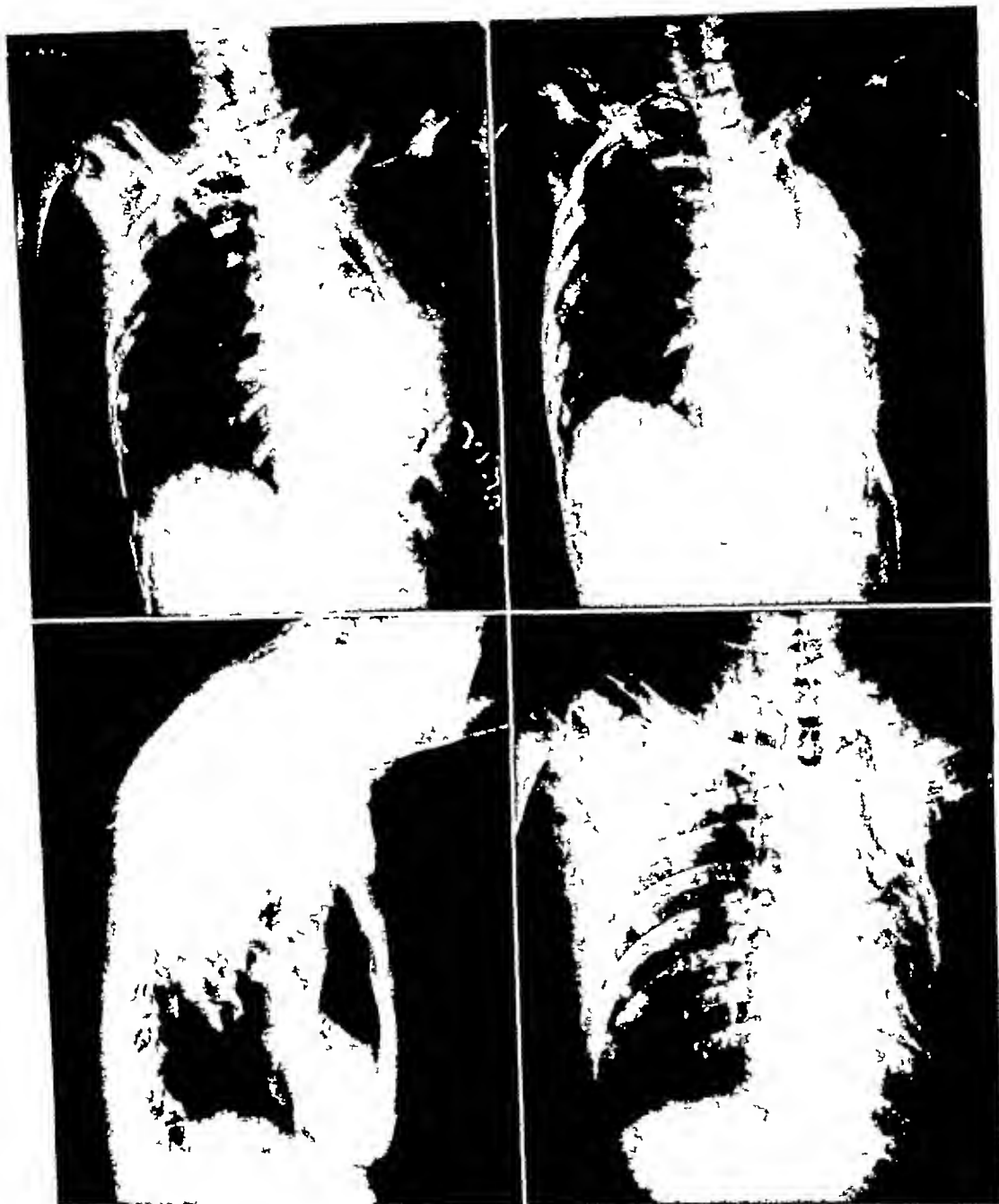


Fig 29 (upper left) Same case as Fig 30
Fig 31 (lower left)

Fig 30 (upper right) Same case as Fig 29
Fig 32 (lower right)

has failed to yield a persistently negative sputum over a period of several months, a revision operation is advisable rather than a third stage. In cases in which there is a caseous pneumonic lesion in the contralateral lung, a third-stage procedure on the original side, if contemplated, should

be withheld until the contralateral lesion is controlled (Fig 25). This permits one to increase the degree of collapse on the contralateral side with less respiratory embarrassment.

In the third-stage thoracoplasty the downward collapse of the lung is mini-

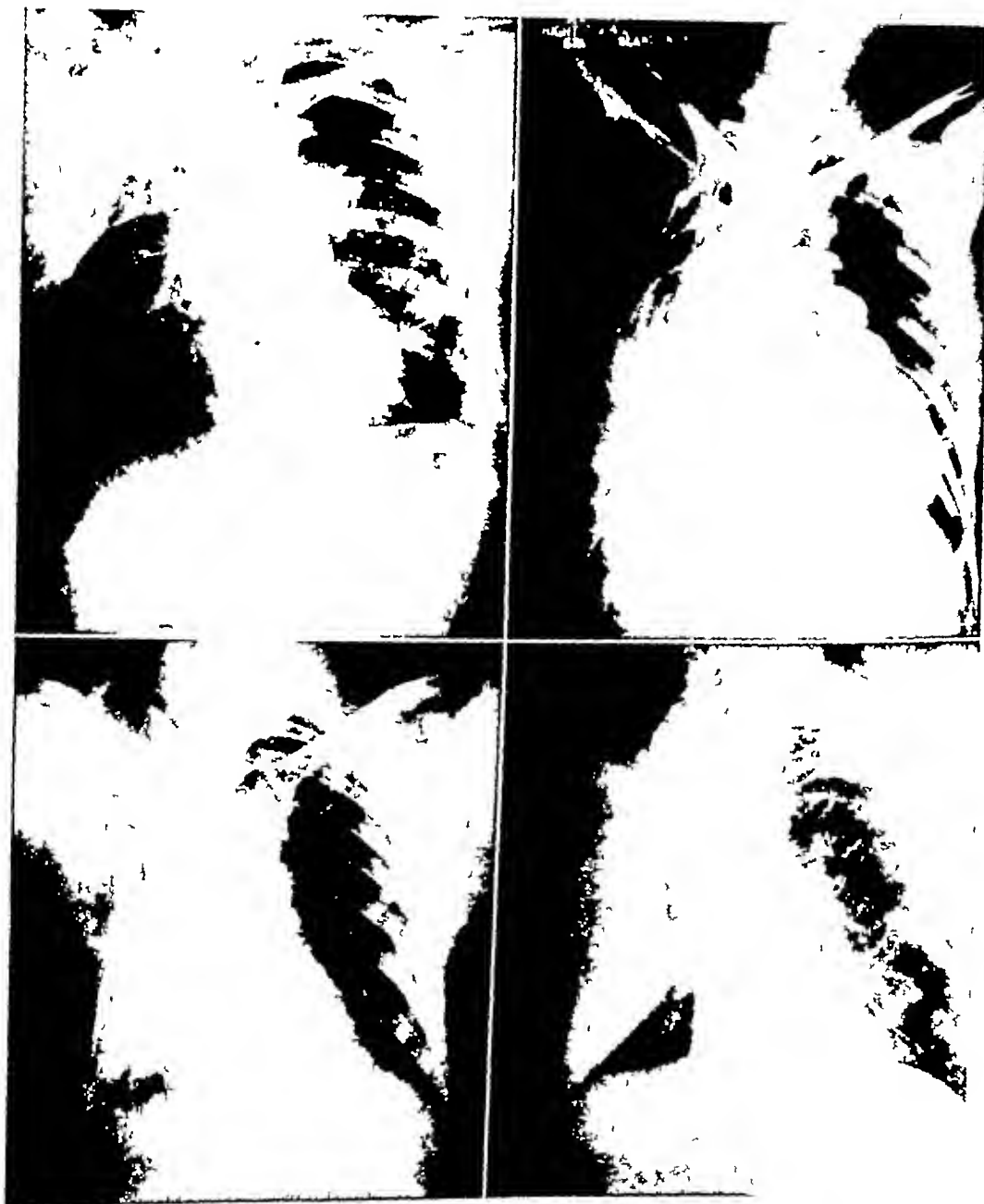


Fig 25 (upper left)
Fig 27 (lower left)

Fig 26 (upper right)
Fig 28 (lower right)

in the cervical and lumbar regions (Figs 26, 27, 29, 30, 34) The findings in the wound are similar to those in the first and second stages but less extensive

In cases in which the cavity was originally large even though it appears obliterated by the routine two-stage thora-

coplasty, a third stage is deemed advisable On the other hand, in cases in which the cavity was small and the sputum remains persistently negative, a third stage as a rule is unnecessary In those in which the cavity was originally small and a two-stage procedure has been performed but



Fig 33

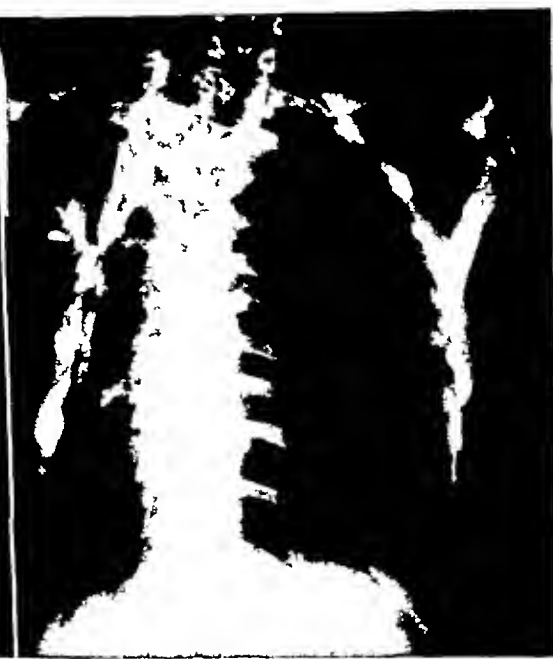


Fig 34

air is not aspirated the parietal pleura with its adherent costal periosteum is held out in the semi-collapsed state. As a result of rib regeneration, this position becomes permanent, unless completely revised. With the absorption of the pneumothorax the lung re expands, filling the pleural space, thereby defeating the purpose of the thoracoplasty.² The re-expansion of the lung is indicated on the roentgenogram by a bulging of the upper lateral chest wall (Figs 29, 30, 33).

The routine thoracoplasty produces a general narrowing of the chest with retraction of the tissues to the affected side. The entire hemithorax assumes a triangular configuration with the base toward the diaphragm. The contralateral lung becomes emphysematous and hypervascularized (Figs 24, 27, 28).

Routine anteroposterior and postero-anterior roentgenographic studies of the post-thoracoplasty chest do not always give all the information about the thorax that it is possible to obtain. In cases in which additional information is desired

² The subject of thoracoplasty in the presence of pneumothorax will form the basis of a subsequent communication.

various alterations in technic may be used, such as (1) the over-exposed or Bucky film to demonstrate the condition of the collapsed lung, (2) the method of Sampson and Gershon-Cohen in which a double exposure is obtained on the same film, producing an over-exposure of the side operated upon and a normal exposure on the side not operated upon, and (3) the stereoscopic roentgenogram to help separate otherwise confusing shadows.

201 Linden Boulevard (L. A. H.)
700 Ocean Avenue (L. N.)

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mial, the collapse being almost entirely from without inward. Compared to the first and second stages there is less depression of the lung and cavity and less atelectasis (Figs 23, 24). As a result, only that pathology located toward the periphery of the lung and not adherent high up, will be appreciably affected. The third-stage procedure is of little benefit in cases in which the original cavity was located in the apex of the lung and failed to drop following the first and second stages. In such instances, a radical revision of the upper regenerated ribs is necessary. Before this is undertaken, roentgenographic studies are made for the location and position of the uncollapsed cavity, and from these studies the course of the revision is planned. Here, usually, regenerated and previously unresected ribs are removed. Considerable cartilaginous regeneration may be present which is not visible on the roentgenogram, so that the extent of the surgical procedure cannot always be judged until the operation is being performed. The surgical procedure is usually greater than the roentgenogram would indicate. This revision operation may follow any stage, whenever the surgeon feels that the results of the previous procedure are unsatisfactory. Frequently, in addition to this revision, pressure is necessary to collapse a large thick-walled cavity. This may be obtained by means of a pressure packing applied outside of the pleura against the decollated lung (Figs 29, 30, 32).

In this stage, the mediastinum is shifted to the contralateral side much more than in the first and second stages, the result of greater lateral pressure exerted by the collapsed lung. The displacement of the mediastinum will depend on its mobility and the number of ribs removed. Accompanying this shifting there is further rotation of the heart (Figs 26, 27). With all these changes there is an increased pressure in the narrowed hemithorax and as a result the diaphragm becomes further depressed and flattened (Figs 26, 27).

In addition to the scoliosis usually seen

in this stage, there may be an accompanying kyphosis, due in part to the loss of muscular support of the spine and in part to the post-operative posture of the patient. The deformity may become permanent as a result of bony regeneration of the ribs, fixing the spinal column in that position. Early corrective exercises are necessary to prevent gross spinal deformities. The prominence of the sternum at this time (Fig 31) is the result of the removal of the ribs on one side and the rotatory scoliosis. The findings in and about the wound are essentially the same as in the previous two stages, but being a relatively simpler procedure, there is less surgical trauma and therefore the changes in the tissues are less pronounced.

After the completion of the thoracoplasty bony regeneration takes place in the area of resected ribs, the end stage of which is the formation of an irregular bony, hard plaque (Figs 26, 34). The direction of regeneration bears no relationship to the original position of the costal structures. This bony wall forms a dense cage on the outside of the parietal pleura to which the periosteum was left adherent at the time of the subperiosteal resection of the rib. The regeneration of the ribs as seen on the roentgenogram gives an indication of the direction the pleura has taken in its collapse following thoracoplasty (Figs 26, 27, 32, 34). Some time after the completion of the thoracoplasty the mediastinal structures are pulled back toward the operative side by fibrotic contractions in the lung. However, the mediastinum is not completely repositioned in its normal position (Figs 24, 28, 32). It may be retracted toward the affected side to a varying degree.

Thoracoplasty not infrequently follows an unsuccessful pneumothorax, *i.e.*, in cases in which pneumothorax has failed to collapse the diseased area. The presence of air in the pleural space at the time of surgical intervention interferes with the collapse of the lung by thoracoplasty, by preventing the coaptation of the parietal and visceral pleurae. If this

While scientific reasons can be advanced for a belief in the importance of other factors (*e g*, target-skin distance of not less than 50 cm and kv p of not less than 200), the indications are that some variation in these factors is permissible.

Since the results of Coutard therapy in treatment of cancer of the larynx, pharynx, and hypopharynx have been so far superior to any present or previous method, no other procedure should be considered when x-ray treatment for the disease in this location is indicated. The same statement holds for cancer in certain other organs, for example, cervix, breast, bladder, esophagus, bronchus, and rectum, although it is often necessary to modify the dosage depending on size and location of the tumor and condition of the patient.

Let us now consider the possibility that there may be special types of tumor in which results from Coutard therapy may be inferior to results with single massive doses or some other technic of radically different type. It has always been obvious that in those lesions which respond to Coutard therapy better than to "massive doses," the advantage of the protracted fractional dose method must rest upon the existence of a more rapid "recovery rate" in the skin than in the tumor. In other words, if the cells of a tumor are able to recover from the effects of radiation more rapidly than the cells of the overlying skin, the net result of protraction will be a loss. There will be a greater accumulation in the skin and a relatively less pronounced effect in the tumor.

Theoretically there is reason to suppose that cells with relatively high metabolic rates will exhibit relatively rapid rates of recovery from toxic effects, including the effects of radiation, furthermore, that cells undergoing very rapid mitosis tend to have elevated rates of metabolism. On such theoretical grounds as the above one expects to find at least an occasional, very rapidly growing neoplasm which merits treatment by a massive single-dose technic.

Turning now from theory to practice, we

may cite the case of Mrs W, who received a protracted fractional dose series in June, 1931, and a short, more intensive three-day series three months later. Her rapidly growing lymphosarcoma of the tonsil regressed only partially after the first (protracted fractional) series, resumed rapid growth in September and regressed rapidly and presumably completely after the short intensive series. Three years later when she died a cardiac death, this patient was still apparently free from recurrence of her tumor. It is our conviction that were we more often in a position thus to compare the relative efficiencies of "protracted fractional" and "massive dose" technics, in the same patient and for the same tumor it would soon become a matter of common knowledge that there are tumors requiring massive doses just as surely as there are tumors that require the method of Coutard.

(In a consideration of the indications for a "massive dose" method, it should be remembered that certain very small superficial growths are completely destroyed by a single large dose of from 3,000 to 5,000 r with complete assurance that the resulting ulcer, of small size, will completely heal. An example would be a small or moderate sized, isolated nodule of recurrent breast cancer in an accessible or superficial location. Such a lesion would undoubtedly respond well to Coutard therapy, but considerations of justifiable economy and common sense dictate the use of a large single dose.)

In the foregoing discussion we have cited tumor types which require "protracted fractional" methods (slow growing tumors, mostly of epithelial origin), and tumor types which, in our opinion, require a "massive dose" technic (certain highly anaplastic tumors such as a very rapidly growing lymphosarcoma of the tonsil). Are there perhaps still other technics, particularly applicable to certain special tumor types not included in the above groups? We believe that there is at least one such.

In the past we have been impressed by the very serious damage which occurred in the skin and subcutaneous tissues of certain

SHOULD THE METHOD OF COUTARD BE APPLIED IN ALL CASES OF CANCER TREATED BY ROENTGEN RAYS?¹

By W EDWARD CHAMBERLAIN, M D, and BARTON R YOUNG, M D, Philadelphia

From the Department of Radiology, Temple University Medical School and Hospital

THE Coutard method is based on the observations of Regaud (1), who found that a single dose of x-rays sufficient to sterilize a rabbit's testicle produced severe skin and tissue destruction, but if this same total dose of x-rays was administered in small fractions, over a number of days, sterilization was produced without significant effect on the skin and subcutaneous tissue. Coutard (2) utilized this knowledge in the treatment of cancer and evolved an entirely new principle, that of administering a large total dose of x-rays to a tumor by giving small fractions of the total dose daily over a long period of time in days. Although the dose was sufficiently large to either partially or completely sterilize the tumor, the integrity of the skin, subcutaneous tissues, and blood vessels was not seriously impaired.

Roentgen therapists who apply the method of Coutard should not be expected to adhere to a rigid technic since the originator of the method follows none. The system used by Coutard (deciding twice per day what field size and dose to apply) is unscientific. The condition visualized at any given observation is the result not of the most recent radiation (six to 24 hours before) but of the treatment or treatments many days previously. We believe it is much more scientific to lay out a plan of therapy at the start, based upon location, size, microscopic appearance, and presence or absence of complications, and then adhere as closely as possible to it. Coutard learned that it is necessary to destroy the superficial epithelium and from experience decided that the daily fractions must be continued for from 20 to 40 days, depending upon histologic nature, location, and size of the tumor.

Many of the patients were treated twice daily, in the morning and afternoon. The technical factors employed by him are as follows: low milliamperage, 4-5, low intensity, from 2.5 to 4 r per minute, heavy filtration, 2 mm Cu plus 2 mm Al, 50-70 cm target-skin distance, and approximately 200 kv p (the kv p was less in the earlier years of study).

It is interesting to study the innumerable modifications, there being almost as many technics as radiologists. However, in a general way those who use Coutard methods can be placed in one of two large groups, *viz*, those who attempt to follow the method rather rigidly and those who have accepted the principle but modify the technic to suit their individual needs. Since we ourselves belong to the former group we feel that we are in a stronger position to point out superstitions and separate them from facts. Such an attempt by one who has been using a modified Coutard technic might be considered as a defense of his method rather than an unbiased analysis. Much emphasis has been placed on the advisability of using low intensity (not more than 5 r per minute), highly filtered (2 mm Cu) x-rays, but although we ourselves have strictly adhered to this part of the technic, we know that comparable results have been obtained with a high intensity, inferiorly filtered (0.5 mm Cu) beam. The splendid results obtained at the Memorial Hospital, of New York City, in treatment of cancer of the larynx and hypopharynx, with high intensity, 0.5 mm Cu filtered x-rays, and the experimental work of McWhurter (3) indicate that these two factors may be varied. We ourselves believe that the essential factors in the method of Coutard are (1) frequent (for example, daily) doses of relatively small fractions and (2) protraction as stated above, until covering epithelium is lost.

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While scientific reasons can be advanced for a belief in the importance of other factors (*e g*, target-skin distance of not less than 50 cm and kv p of not less than 200), the indications are that some variation in these factors is permissible

Since the results of Coutard therapy in treatment of cancer of the larynx, pharynx, and hypopharynx have been so far superior to any present or previous method, no other procedure should be considered when x-ray treatment for the disease in this location is indicated. The same statement holds for cancer in certain other organs, for example, cervix, breast, bladder, esophagus, bronchus, and rectum, although it is often necessary to modify the dosage depending on size and location of the tumor and condition of the patient

Let us now consider the possibility that there may be special types of tumor in which results from Coutard therapy may be inferior to results with single massive doses or some other technic of radically different type. It has always been obvious that in those lesions which respond to Coutard therapy better than to "massive doses," the advantage of the protracted fractional dose method must rest upon the existence of a more rapid "recovery rate" in the skin than in the tumor. In other words, if the cells of a tumor are able to recover from the effects of radiation more rapidly than the cells of the overlying skin, the net result of protraction will be a loss. There will be a greater accumulation in the skin and a relatively less pronounced effect in the tumor.

Theoretically there is reason to suppose that cells with relatively high metabolic rates will exhibit relatively rapid rates of recovery from toxic effects, including the effects of radiation, furthermore, that cells undergoing very rapid mitosis tend to have elevated rates of metabolism. On such theoretical grounds as the above one expects to find at least an occasional, very rapidly growing neoplasm which merits treatment by a massive single-dose technic.

Turning now from theory to practice, we

may cite the case of Mrs W, who received a protracted fractional dose series in June, 1931, and a short, more intensive three-day series three months later. Her rapidly growing lymphosarcoma of the tonsil regressed only partially after the first (protracted fractional) series, resumed rapid growth in September and regressed rapidly and presumably completely after the short intensive series. Three years later when she died a cardiac death, this patient was still apparently free from recurrence of her tumor. It is our conviction that were we more often in a position thus to compare the relative efficiencies of "protracted fractional" and "massive dose" technics, in the same patient and for the same tumor it would soon become a matter of common knowledge that there are tumors requiring massive doses just as surely as there are tumors that require the method of Coutard.

(In a consideration of the indications for a "massive dose" method, it should be remembered that certain very small superficial growths are completely destroyed by a single large dose of from 3,000 to 5,000 r with complete assurance that the resulting ulcer, of small size, will completely heal. An example would be a small or moderate sized, isolated nodule of recurrent breast cancer in an accessible or superficial location. Such a lesion would undoubtedly respond well to Coutard therapy, but considerations of justifiable economy and common sense dictate the use of a large single dose.)

In the foregoing discussion we have cited tumor types which require "protracted fractional" methods (slow growing tumors, mostly of epithelial origin), and tumor types which, in our opinion, require a "massive dose" technic (certain highly anaplastic tumors such as a very rapidly growing lymphosarcoma of the tonsil). Are there perhaps still other technics, particularly applicable to certain special tumor types not included in the above groups? We believe that there is at least one such.

In the past we have been impressed by the very serious damage which occurred in the skin and subcutaneous tissues of certain

patients Strangely enough, these patients were not the ones who had received large individual doses or repeated daily fractions with high total dosage Analysis of their records revealed that they had received either small or moderate doses at weekly, bi-weekly, or monthly intervals for many months It was quite apparent that this type of radiation had been more damaging to the blood supply than any other type The question now arises as to whether this tendency (for an interval of about one month between treatments to destroy or diminish the blood supply) may be put to clinical use Our own experience indicates that it can, and we give serious consideration to a plan of monthly doses of from 300 to 800 r (usually in a three- or four-day series) whenever we are faced with (1) a highly radioresistant tumor and a histology that indicates a high degree of tissue differentiation (examples—fibrosarcoma, neurofibroma, metastasizing thyroid adenoma), or (2) when the element of vascularity is an important factor (examples—hemangioma, certain telangiectatic tumors of the spinal canal, some highly vascular but relatively radiation-resistant sarcomas of bone) While the literature appears not to contain any analytical allusions to this type of technique, it is obvious that Newcomet (4), Ewing (5), Ginsburg (6), and others have consciously or subconsciously adopted some such method

Entirely aside from the fact that attempts to apply the method of Coutard to all tumors are bound to result in depriving at least an occasional case of a more fitting type of treatment, there is a further reason for avoiding the large total dose and violent reaction of a Coutard series, except when the indications for same are quite definite We refer to the danger that serious skin lesions may develop, in the distant future, if not sooner An indication of the remarkable latency of some of these late roentgen catastrophes is to be seen in the following case history

Case Reports—R S, white male, aged 46 years, received x-ray therapy over his face for acne, in 1910, at the age of 20 years

(26 years ago) During the ensuing 20 years he had no reason to suspect that he had suffered injury In retrospect he now realizes that he needed to shave only about twice per week, while his friends found it necessary to shave daily Nevertheless, his first inkling of trouble came in 1930 when a friend called his attention to a certain "pinched look" about his nose and chin Between 1930 and 1935 he progressively developed atrophy, telangiectasia, and multiple epitheliomas that have necessitated plastic surgery of an extensive type Our reason for citing this admittedly very unusual case is to call attention to the possibility that skin lesions more serious than we now anticipate, may be in store for us in those cases that may be destined to live 20 or more years after they have undergone a Coutard series Such a possibility would seem to contra indicate the use of such a radical method of treatment except in cases in which the indications are quite definite and the condition in need of treatment a serious one

SUMMARY

The two essential factors in the method of Coutard are (1) frequent (for example, daily) doses of relatively small fractions, and (2) protraction until a very large total dose has been administered Within certain limits such other factors as target-skin distance, voltage, filter thickness, and r-afflux (r per minute) are non-essentials or objects of superstition rather than accurate knowledge

The method of Coutard is so far superior to other forms of roentgen therapy in certain cancers that the use of any other method is inconceivable Despite this fact, any attempt to apply it universally in the x-ray treatment of malignancy is a serious mistake Intelligent treatment is based upon individualization, with careful attention to such factors as size and location of tumor, histopathology, and general condition of patient In the present paper we have cited instances of tumors that require treatment by the single massive dose

method and other tumors that are certainly resistant to either the massive dose or the Coutard method, yet may respond favorably to a special type of irradiation consisting of moderately large doses (usually in the form of a three- to four-day series) at (approximately) monthly intervals

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INTERLOBAR EFFUSION ASSOCIATED WITH HEART FAILURE¹

By JOSEPH LEVITIN M D , Roentgenologist, Mount Zion Hospital, *San Francisco*

INTERLOBAR effusion is associated in the minds of most general practitioners with infection in the lungs. The usual source of infection is pneumonia, lung abscess, or tuberculosis. That it can occur as an aseptic effusion has been recognized by a few observers. A common cause of aseptic effusion which should be kept in mind by those interested in diseases of the chest is an effusion occurring with cardiac failure.

lobar effusion in a case of cardiac failure. The heart disease was a primary atherosclerosis. The effusion disappeared with recovery of the patient and reappeared with the subsequent cardiac failure. The accumulation of the fluid was a primary pleural process and was due to previous obliteration of the peripheral pleural cavity, leaving the interlobar space as the only one into which transudation could occur.

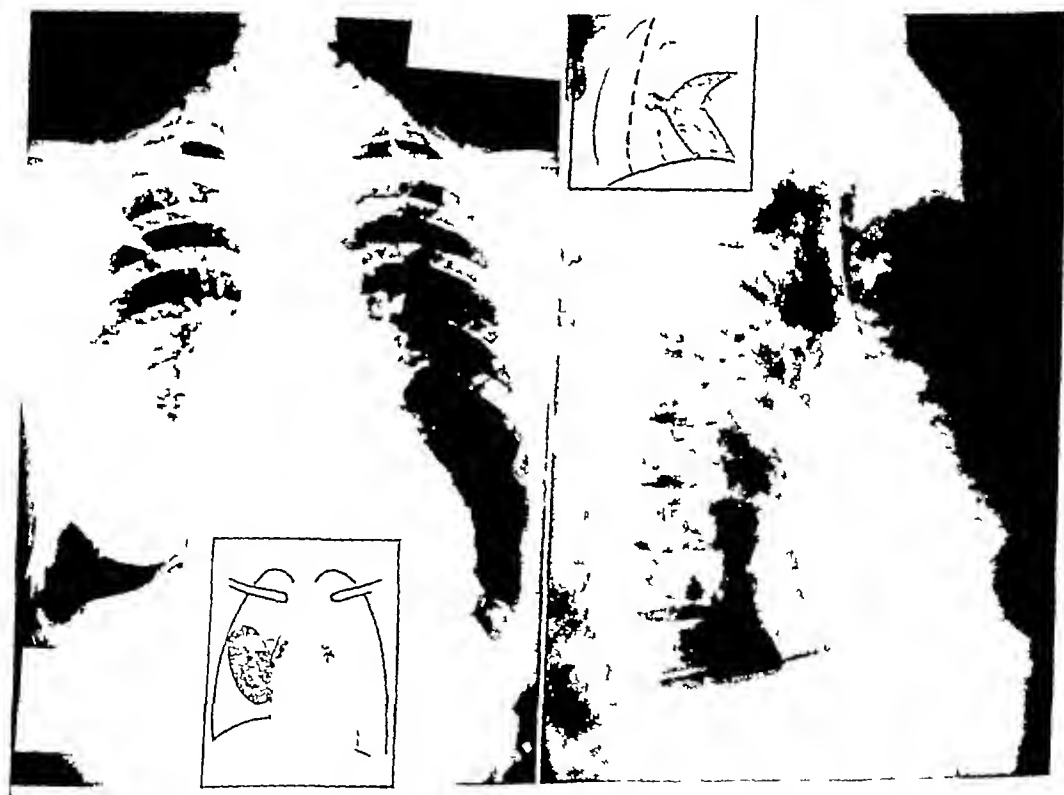


Fig 1 Interlobar effusion between the lobes on the right side

Stewart (1), in 1928, was the first to describe the occurrence of encapsulated inter-

¹From the Department of Roentgenology Mt Zion Hospital and the Department of Surgery, Division of Thoracic Surgery, University of California Medical School Service of Dr Brunn

In addition to this case of Stewart's, Kiser (2), in the next year, reported a case of myocardial failure with congestion. Steele (3), in 1931, reported two additional cases in which interlobar fluid appeared, in the right upper half of the chest, with

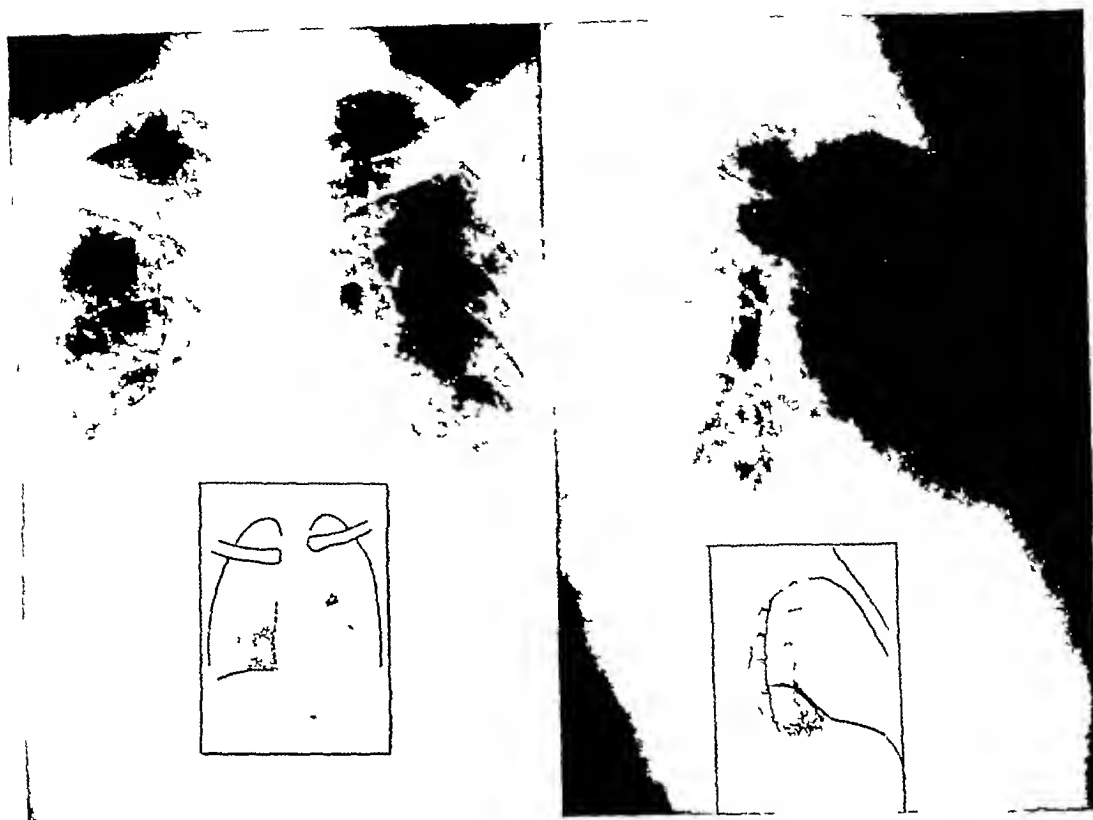


Fig 2 Interlobar effusion between right middle and lower lobes Pleural effusion right base

recurrent attacks of heart failure, and disappeared with the disappearance of the edema and with general recovery. These shadows reappeared with the second attack. One case came to autopsy and showed obliteration of all pleural spaces except the one between the upper and middle lobes, where 250 c.c. of fluid was found. For the effusion to be limited to the interlobar space, Steele concluded that extensive adhesions are necessarily antecedent to the development of the heart failure.

In 1931, Freedman (4) reported a case of effusion between the right upper and middle lobes. This patient had a coronary occlusion and an aneurysm of the left ventricle. Freedman emphasized the fact that interlobar effusion must be differentiated from localized marginal pneumonia and bronchial carcinoma. He further stated that in the presence of a pneumonia the only x-ray sign of interlobar effusion

is a bulging of the interlobar fissure seen in the lateral view.

Austrian (5), in 1932, reviewed the literature and added his own case which showed an interlobar effusion during periods of congestive heart failure. At postmortem there was found an antecedent obliterative pleurisy, probably of tuberculous origin, so that the interlobar space was the only one in which the fluid could accumulate. All of the cases he reviewed had coronary disease or disease of the aorta near the ostia of these vessels. The fluids found were all on the right side.

Stein and Schwedel (6), in 1934, stated that interlobar effusion in patients with cardiac failure is not uncommon. The cases they described also occurred with pleural effusion.

Rigler (7) reviewed 18 cases with interlobar effusion, which were all right-sided, and concluded that in heart disease it may arise as an exudate from a pleurisy or

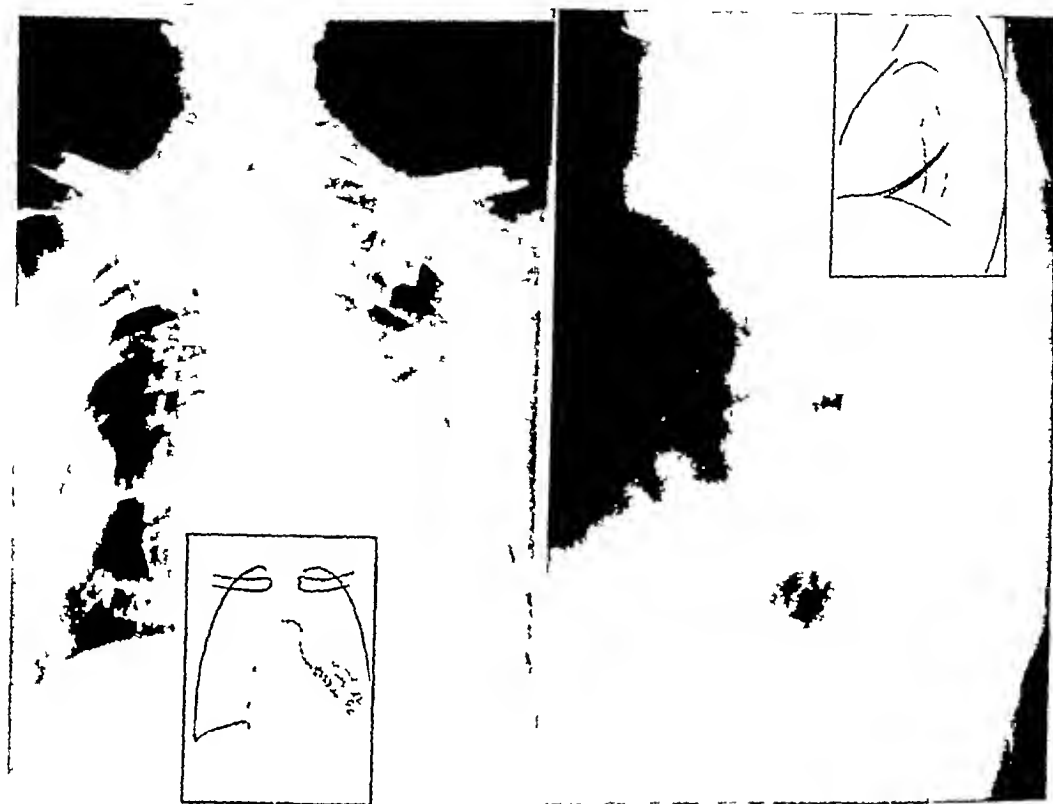


Fig 3 Interlobar effusion on left side Encapsulated effusion in right axilla

pericarditis in the course of active rheumatic fever, following an infarction along a pleural surface, or during cardiac decompensation. This results in a transudation from congested lungs and pulmonary stasis. In these cases there were no preceding histories of pneumonia or pleurisy, but it was thought that during cardiac decompensation and repeated bouts of failure, pleural reactions occur which lead to thickenings. The interlobar pleuræ are least affected by the thickenings because pleurisy is more common between the visceral and parietal pleuræ, spreading rapidly with respiration. Drainage of the interlobar pleura is facilitated by two areas of lung surfaces, while the pleural cavity has a rigid chest wall and only the visceral surface for absorption. Fluid also gets into the interlobar space by seepage from the general pleural cavity.

Shuflett (8) discussed the subject, added two cases to the literature and emphasized

the lack of clinical symptoms. He warned against confusing these shadows with metastatic malignancy.

The diagnosis of interlobar effusion is facilitated by an x-ray in the postero-anterior and lateral views. In the postero-anterior view the appearance of the interlobar effusion will depend upon the fissure in which the effusion occurs. In a previous article (9) we demonstrated the appearance of effusions occurring in the different fissures and found that broad shadows are obtained by effusions along the oblique longitudinal fissure bordering the lower lobe and a narrow band shadow if the effusion occurs between the upper and middle lobes. The lateral view is most important in differentiating this shadow from either a pneumonic consolidation or general effusion in the pleural cavity. In this view a definite band or shadow of elliptical shape, depending upon the amount of effusion, will be clearly demonstrated.

There is no doubt but that interlobar effusion is more common than is usually recognized, as it may be masked by a general pleural effusion

In reviewing our series of interlobar effusions, we have found three cases which were the result of cardiac decompensation

CASE REPORTS

H K, a male, 51 years of age, entered the service of Dr Kerr, at the University of California Hospital, suffering from marked dyspnea, orthopnea, and cyanosis. He had a positive blood Wassermann. Physical examination showed fluid in the left chest. Heart Apex beat in the fifth interspace, 12 cm from the midsternal line. He had a diastolic and a systolic murmur over the aortic area, moderately sclerotic peripheral vessels and a Corrigan type of pulse with marked capillary pulsation. Blood pressure was 220/30 in the left arm and in the right arm 180/30. X-ray examination showed interlobar effusion between the lobes on the right side and fluid in the left chest. Under treatment of digitalis, digifolin, caffeine, and thorocentesis he improved and was discharged. He re-entered one month later with the same symptoms and re-accumulation of fluid. On the second entry there was a gradual increase in aortic insufficiency with resulting cerebral anoxemia and mental changes. He died following an accident and at autopsy fluid was found in the left chest, and the right pleural cavity was obliterated by dense fibrous adhesions. Encapsulated fluid was demonstrated in the interlobar fissure and also some at the base.

L C, aged 57, entered Mt Zion Hospital on the service of Dr Briggs, with the complaints of dyspnea, orthopnea, and edema of the extremities. A diagnosis of arteriosclerotic heart disease with decompensation and auricular fibrillation was made. X-ray examination of the chest showed fluid at the right base and between the middle and lower lobes. With bed-rest and digitalis medication the edema cleared, the

fluid disappeared, and the patient left the hospital.

H F, aged 74 years, entered the service of Dr Briggs at Mt Zion. This patient complained of a progressive dyspnea on exertion for the past two years. He entered with physical findings of cardiac failure, edema of the extremities, and a heart enlarged to the left. X-ray showed interlobar effusion on the left side and encapsulated in the right axilla. With digitalis and rest the effusion cleared in two days.

CONCLUSION

As one of the causes of interlobar effusion one must keep in mind that of heart failure. If there is an obliterative pleuritis, the effusion will occur only between the lobes. This fluid disappears with the general improvement of the patient and does not require any specific therapy other than treatment of the decompensation. Roentgenograms should be taken in the postero-anterior and lateral positions. The lateral position is most important, as it is in the plane of the fissure. The appearance of the effusion within the fissure may be in the form of a band or ellipse, depending on the amount of the effusion.

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AN ATTEMPT TO INVOLUTE COMPLETELY ALL OF THE LYMPHOID TISSUE OF THE ALBINO RAT BY X-RAYS

By CHARLES W. HUGHES, M.S., M.D., and THESLE T. JOB, Ph.D., Chicago

From The Department of Anatomy, Loyola University School of Medicine

IRRADIATION of the thymus has been resorted to by clinicians for the past twenty years to correct respiratory stridor in infants, and it has been done as a pre-operative procedure when respiratory difficulties were present. In the course of such treatment, some clinicians have observed deleterious effects (5), while others have observed no injurious effects (1, 7). Observations of the results of thymectomy have been extensive and productive of controversy (8). Is there a correlation of function of the thymus gland and other lymphoid tissue including the tonsils, lymph nodes, and spleen? Are the results of thymectomy so indefinite because the remaining lymphoid tissue supplants the thymus gland? The answers to these and many other similar questions have not been completely demonstrated.

In 1927 Wintz (11) used x-rays to destroy the germinal epithelium in ovaries without apparently injuring other ovarian tissues. In 1926 Suzuki (10) found that the lymphocytes, lymphoid tissue, thymus gland, and testes of the rabbit were sensitive to x-rays in the sequence indicated. These facts made it seem possible that small doses of x-rays should destroy at least a major portion of all the lymphoid tissues, including the thymus gland, without detrimental effects to other tissues. If an animal with no lymphoid tissue and all other tissues normal could be prepared and observed, the results should be interesting.

Consequently, the object of this research was to cause by means of a definite dose of x-rays a differential involution of all, or as much as possible, of the lymphoid tissues of albino rats and then to observe the effects of such an involution on the growth, development, and subsequent physiologic behavior of the rat. We hoped that these observations might aid in answering some

of the foregoing questions and in determining the functions of the thymus gland and other lymphoid tissue.

As the work progressed the results obtained necessitated the use of a variety of procedures. For this reason, procedure and results are described together.

A method for involuting lymphoid tissue without injuring other tissues was suggested by the work of Bienfait (2) in 1928. He stated that irradiation of the spleen stimulated the production of lymphocytolysin which was distributed in the blood and caused cytolysis of lymphocytes. If it were possible to destroy lymphocytes in lymphoid tissue by irradiating the spleen alone while the rest of the body was protected, the conditions for the above observations would be ideal because the danger of x-ray effects on tissues other than lymphoid tissue would be slight. The following experiment was attempted to test this possibility.

Five 40-day-old rats were anesthetized with ether or sodium barbital and the spleen was drawn through an incision in the abdominal wall and rayed, while the rest of the body was protected completely by a lead shield. The spleen was then replaced in the abdominal cavity and the incision was sutured. From five to seven days later the rats were killed and the thymus glands were examined. The results of the few experiments performed are tabulated in Table I.

These results indicate to us that attempts to produce an appreciable involution of lymphoid tissue by stimulating the spleen to produce lymphocytolysin were not practical. Ferroux, Gayet, and Jolly (4), in 1927, stated that involution of lymphoid tissue by the indirect effect of x-rays does not occur.

It was apparent then that we must resort

TABLE I—NEGATIVE EFFECTS OF SPLENIC IRRADIATION ON THE THYMUS

Sex	Age (days)	Dose	Body Weight	Days following raying when rat was killed	Thymus Weights	
					Rayed Rats	Normal
M	40	216 r	100 gm	5 days	0.322 gm	0.360
F	41	360 r	120 gm	6 days	0.412 gm	0.360
F	39	468 r	93.7 gm	7 days	0.415 gm	0.360
M	40	1,040 r		6 days	No gross change	0.360
F	40	1,040 r		7 days	No gross change	0.360

In this table "No gross change" indicates that the thymus was not weighed but that it appeared to be of normal size.

to the direct effects of x-rays and irradiate the whole body of the rat if we wished to demolish all of the lymphoid tissue. To test the practicability of this procedure five two-day-old rats were exposed to 280 r and ten to 360 r. Some of these rats were killed a short while after irradiation and others months later. Their thymus glands were examined grossly and microscopically

tissue but not so much as we had hoped to obtain. A more definite involution was caused by 360 r but there resulted, also, a delay in the appearance of hair over the entire body, anemia, stunted growth, and a peculiar nervous complex. This complex was characterized by weakness, partial paralysis, intentional tremor of the extremities, and impaired equilibration. The

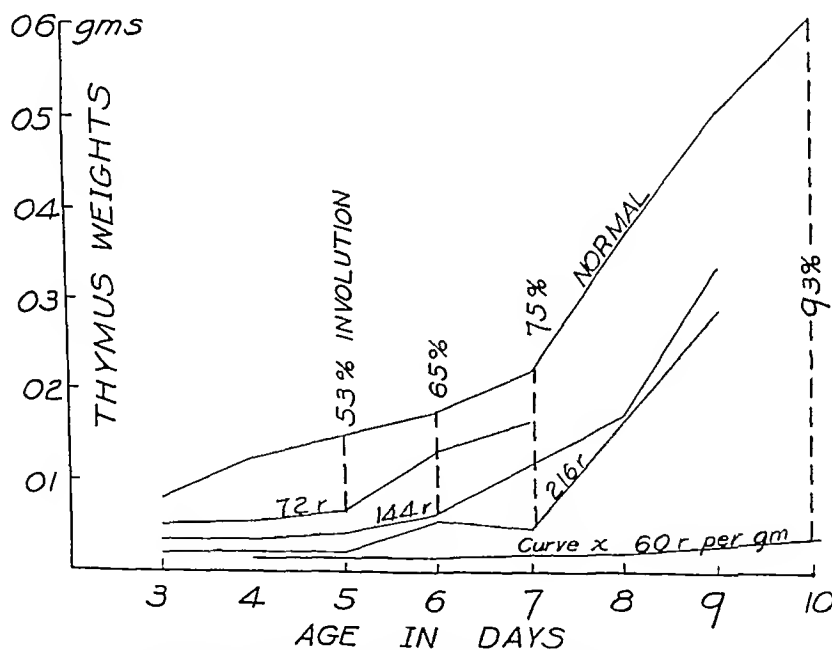


Fig 1. A comparison of the effects of increasing doses of x rays on the thymus gland. The vertical interrupted lines mark the maximum extent of separation between the normal curve and the respective abnormal curves. The percentage figures associated with the interrupted lines express the maximum percentage by weight of involution. Sixty r per gram body weight, the dose indicated on the lower curve, is equivalent to a total dose of 360 r. Curve x was made by the use of data obtained from an experiment which is described toward the end of the paper.

The results of these examinations were used as an indication of the extent of involution of other lymphoid tissue in the body (Tsuzuki, 10). It was found that 280 r produced some involution of lymphoid

smaller dose, 280 r, produced no such complex. When as much as 600 r were administered to rats while their heads were protected by a one-sixteenth inch lead shield, no nervous symptoms developed.

Since 600 r produced no nervous complex when the head was covered, it appeared that the brain was the portion of the body involved in the production of the complex.

We concluded from the results of this group of experiments that a dose of x-rays large enough to produce an appreciable involution of lymphoid tissue inflicted an

attempt to establish a method of irradiation that might effectively involute all the lymphoid tissue except that in the head.

To accomplish this purpose different doses of x-rays, 72, 144, and 216 r, were administered to 60 two-day old rats while their heads were protected by a lead screen. Their body weights were recorded on the

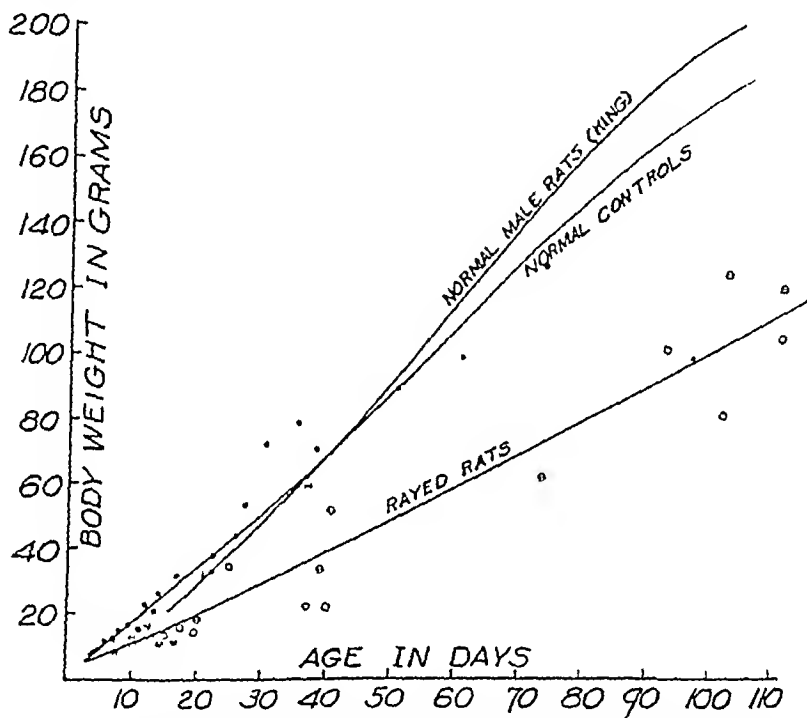


Fig 2 A comparison of the body growth of normal and irradiated rats. There are two normal curves. The upper one was copied from King (6). The lower one is drawn through the black dots which represent the average weights of litter mate controls. The average weights of irradiated rats are plotted as follows, males by "⊖" and females by "○".

injury in the brain which produced many nervous symptoms. It then became apparent that the head of the rats must be protected in subsequent attempts to involute lymphoid tissue. Therefore, the plan to destroy all of the lymphoid tissue in the body of the rats (including the head) was abandoned.

We could foresee at this time numerous difficulties if we were to use doses of x-rays larger than 360 r, because this dose had caused the pathology noted above. We decided to analyze the effects of smaller doses of x-rays on the thymus gland in an

day they were irradiated, and on the day they were killed. They were killed on various days from the third to the tenth. Their thymuses were removed, weighed, and examined microscopically. The data obtained for similar days and doses were averaged and plotted as in Figure 1.

It can be seen in this figure that a dose of 72 r produced its maximum involution of 53 per cent of thymic lymphoid tissue by weight three days following irradiation. Regeneration began on the same day. 144 r caused 65 per cent involution four days following irradiation. When 216 r were

used a maximum involution of the thymus of 75 per cent occurred by the fifth day following irradiation, and regeneration began on that day. These results indicated that as the dosage of x-ray administered to the rat is increased, the amount of involution of lymphoid tissue is increased and the onset of regeneration is delayed.

Superficial observation of the data accumulated in the above experiment indicated that there was a sex difference in the degree of involution of thymuses. In order to investigate this observation the male and female thymus weights were considered separately. The male thymus weights obtained from rats receiving 72, 144, and 216 r units were averaged separately for the third day. These three averages were then averaged. The same was done for the fourth, fifth, sixth, and seventh days. The data for the females were arranged in the same manner, and all of these averages were tabulated in Table II.

TABLE II—SEX DIFFERENCE IN INVOLUTION OF THE THYMUS GLAND BY X-RAYS

Age of rats in days	Average weights of thymus glands irradiated with 72, 144 or 216 r		Average body weights of irradiated rats		Weights of control thymus glands	
	Males (gm)	Females (gm)	Males (gm)	Females (gm)	Males (gm)	Females (gm)
3	0.003	0.004	5.9	6.0	0.007	0.009
4	0.003	0.004	7.3	7.2	0.013	0.013
5	0.005	0.006	8.2	7.6	0.014	0.017
6	0.006	0.0068	9.1	7.7	0.015	0.019
7	0.014	0.009	11.2	8.2	0.0195	0.023
9	0.028	0.035	14.2	14.7	0.042	0.041

The results tabulated in Table II indicate that the female thymus is more resistant to x-rays than the male. In the results tabulated for the seventh day, the opposite condition prevails. This can be explained, however, by the fact that the male rats in this case were three grams heavier than the female rats. When a comparison is made of the normal weights of female and male thymuses in the very young rat (Table II), it appears as though the male thymus is lighter than the female thymus. This is probably the reason for the greater weights of the experimental female thymuses above recorded.

At this point in the development of this problem, we perceived by studying our previous results that the percentage of involution of the thymus gland following irradiation with a constant dose of x-rays was inversely proportional to the weight of the gland. Therefore, we decided that more constant results could be obtained if the dose of x-rays was determined by the weight of the gland. This could be done easily because we discovered that the thymus weights in young rats are directly proportional to the body weights of the rats. Consequently, in all of the subsequent experiments the doses of x-rays are expressed as r per gram body weight.

The results compiled in Figure 1 indicate the ease with which the thymus gland can be involuted, and also the difficulty encountered in preventing regeneration of the involuted gland. Regaud and Crémieu (9), in 1912, demonstrated a reduction in the size and weight of thymus glands of young cats that had been exposed to 14 Holzknecht units of x-rays. On the second day this reduction was detectable. On the fifth day the thymus was reduced 80 per cent of its normal weight and at two weeks 90 per cent of the thymus had degenerated. They also noted that regeneration began on the fifteenth day from lymphocytes which had remained unaffected. We anticipated destruction of the regenerative power of the thymus gland if a second dose of x-rays were given preceding that time when regeneration might begin. Microscopic examinations of the involuted thymus revealed only a few lymphocytes at this time. We hoped that these cells might be killed by a second dose of x-rays and the source of regeneration eliminated.

The following experiment was designed in accordance with these ideas. A dose of 40 or 45 r per gram body weight was given to 24 two-day-old rats while their heads were protected by a lead plate. The same dose was repeated on the fifth day under the same conditions. All of the above animals were controlled by litter-mates. Some of the animals were killed during the first few weeks of the experiment. The

thymuses were removed, weighed, and examined microscopically. Those animals which were not killed early in the experi-

The results obtained thus far indicated to us that attempts to produce a generalized involution of lymphoid tissue without



Fig. 3. The two upper rats had the whole body irradiated except the head. The two lower rats are 20 day-old litter mate controls.

ment were weighed frequently, thus a record of their growth was obtained.

The results of this experiment concerning the thymus gland and lymphoid tissue were discarded because marked delay in growth of the animals resulted. Incomplete involution of the thymus glands was revealed by gross examination. The data demonstrating stunted growth of the animals are presented in Figure 2. Photographs of two irradiated rats and two normal rats are presented in Figure 3 for comparison.

To eliminate the possibility that the stunted growth occurred because of the effects of involution of lymphoid tissue and was not the direct effect of the x-rays, 10 rats were irradiated in the same fashion as those above except that the lead shield covered the cranial part of the body as far down as the xiphoid process of the sternum. In these animals that portion of the body which was exposed to x-rays was definitely stunted in growth, as illustrated in Figure 4. It appeared from these experiments that the retarded growth produced in these rats was a direct effect of the x-rays. Brooks and Hillstrom (3), in 1933, investigated the effects of x-rays on bone growth, and they compiled a large bibliography which dated back to the original work of Perthes in 1903.

injuring other tissues were futile. The fact that a dose of x-rays large enough to produce an appreciable involution of lymphoid tissue inflicted an injury in the brain and stunted growth indicated to us that in all of the remaining experiments the body of the rats must be protected by a lead shield while the x-rays were administered through an aperture over the thymic area.

In the first group of experiments after this new routine was established, an attempt was made to repeat approximately the conditions of the previous experiment in which stunted growth resulted, so that



Fig. 4. The caudal one-half of the lower rat was irradiated. The upper rat is a 35-day-old litter-mate control.

the effects of involution of the thymus gland on body growth could be compared with the results of the previous experiment

accordance with the work of Park and McClure (8), who demonstrated that thymectomy caused no alteration in growth. A

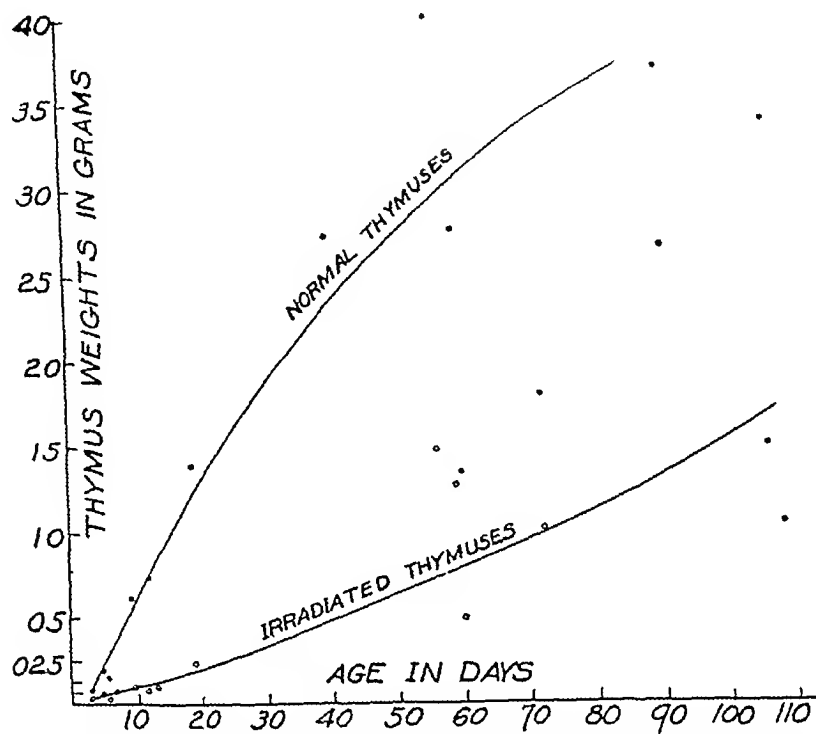


Fig. 5. A comparison of the weights of normal thymuses and thymuses irradiated with two doses of 45 or 50 r per gram body weight. The circles represent the average thymus weights of irradiated rats. The black dots denote the litter mate controls.

Forty rats were irradiated with 45 or 50 r per gram body weight on the second day of life. The same dose was repeated after three days. Litter-mate controls were kept. The rats were killed at various ages ranging from three to 110 days and the thymuses were removed and weighed. The resulting data for similar days were averaged and plotted in Figure 5. Accurate data on the growth of these animals were kept and plotted in Figure 6.

In Figure 5 it can be seen that the irradiated thymuses were partially involuted and remained so until the rats were 110 days old. Complete involution was not obtained. Figure 6 indicates that there was no effect on the body growth of rats when their thymuses were involuted to the extent shown in Figure 5. This result is in

comparison of the growth curve obtained in this experiment with that resulting in the previous experiment reveals quite a contrast.

Because of the fact that the doses of γ -rays given thus far had not produced a lasting involution of the thymus, a series of experiments was performed in which one large dose of γ -rays was administered in an attempt to produce a permanent involution of the thymus. In view of the fact that complete thymectomy is not followed by regeneration of the thymus, and since Regaud and Crémieu (9) state that complete destruction of the thymus of the kitten was caused by the administration of 50 Holzknicht units of γ -ray, it seemed logical to think that a dose of γ -rays which

would produce a complete involution would prevent regeneration of the thymus

One dose of 60 r per gram body weight was administered to 12 two-day-old rats. They were killed on various days following

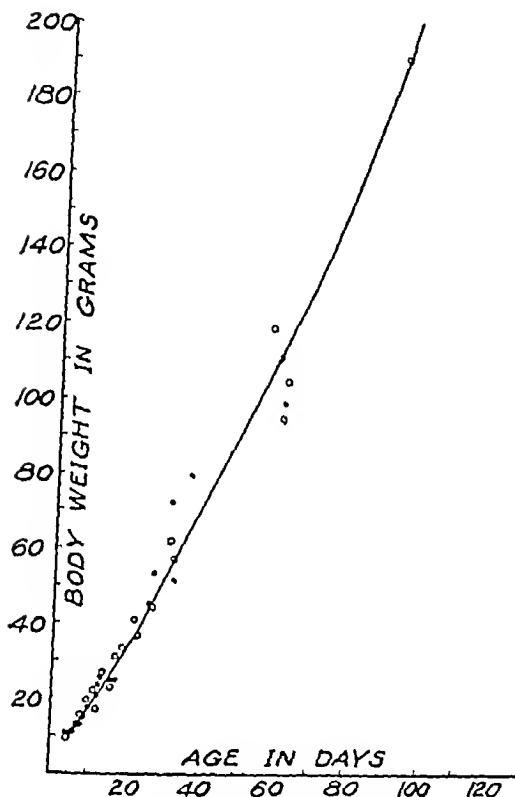


Fig 6 A comparison of the body growth of normal rats and rats following involution of the thymus gland to the extent indicated in Figure 5. The circles indicate the average weights of the irradiated animals. The black dots represent the average weights of normal control animals.

irradiation and their thymuses were removed and weighed. During the eight days following irradiation involution of the thymus gland occurred to the extent of 93 per cent by weight. Even after this amount of involution, regeneration occurred. The data from this experiment were plotted in Figure 1, because they supported the conclusion that as the dose of γ -rays administered to the thymus glands is increased, the percentage of involution is increased and the onset of regeneration is delayed. The curve which was made from

the data of this experiment is indicated in Figure 1, by the letter γ .

At this time we made an inventory of all of the γ -ray doses, to date, in terms of r per gram body weight. We found that single doses of 10, 20, 35, 45, and 60 r per gram body weight and double doses totalling 80, 90, and 100 r per gram body weight had been given.

We decided, therefore, to determine the effects of doses of γ -rays larger than 100 r per gram body weight. When doses of 108, 126, 128, 144, 160, and 216 r per gram body weight were administered to two day old rats a severe γ -ray burn resulted seven days following irradiation. In association with the burn a marked paralysis of the forelimbs occurred. All of the rats died before they were four weeks old, in most instances, death occurring on the thirteenth post-natal day. The parents devoured all of the irradiated rats except eight which we retrieved from the cages. When the markedly atrophied thymus glands from these rats were examined histologically, we found lymphoid tissue in three. In the other five, no lymphoid tissue was demonstrable. Numerous mast cells were seen in all of the glands.

We concluded from this experiment that a dose of γ -rays large enough to produce complete involution of the thymus gland in very young rats caused death to the animals because of marked damage to other tissue.

CONCLUSIONS

1. Gross involution of the thymus gland by the indirect effects of γ -ray irradiation of the spleen does not occur.
2. Irradiation of the whole body of two-day-old rats with 360 r produces a nervous complex which is characterized by an intention tremor and a loss of equilibrium. The site of the lesion is probably in the brain of the rat.
3. As the dosages of γ -rays administered to the thymus glands of two-day-old rats is increased, the percentage of involution is increased and the onset of regeneration is delayed.

4 Growth may be retarded by x-rays. This retardation is a direct effect of the x-rays and appears to have no relation to lymphoid tissue.

5 Partial involution of the thymus gland of rats by x-rays does not affect the growth of the rat.

6 The dosage of x-rays required to produce a complete and permanent involution of the lymphoid tissues of the body is so great that it causes other deleterious effects.

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THE MEASUREMENT OF TISSUE DOSE IN TERMS OF THE SAME UNIT FOR ALL IONIZING RADIATIONS

By G FAILLA, D Sc, Memorial Hospital, New York City

IN radiation therapy it would be obviously of great advantage to choose a unit of dose such that the same biological effect would be produced by a given dose, irrespective of the quality, or even kind, of radiation employed, provided, of course, that all other conditions remained the same. There is enough experimental evidence available to-day to prove that this ideal situation cannot be realized by the adoption of any one unit of dose, in the quality range which includes both ordinary x-rays and gamma rays. It becomes necessary, therefore, to examine the problem with the object of selecting a unit which approaches the ideal one as closely as our present knowledge permits.

Taking for granted the existence of a difference in biological effect produced by radiation of different wave length (irrespective of the unit of dosage) the quasi-ideal unit would be one which makes possible the specification of equivalent biological effect by the smallest number of dosage factors. The smallest possible number in which such a "biological dose" may be expressed, is two—one representing the *quantity factor* of the dose, and the other the *quality factor*, both referring to the point at which the biological effect is produced. By these two factors one must be able to express doses of (ionizing) radiation of any wave length, which are biologically equivalent, when all other conditions are identical. Biological equivalence in this connection must necessarily mean equivalence in the *degree* of effect produced. If the *kind* of effect is different, no comparison at all is possible. In the ordinary therapeutic range of wave lengths, it may be assumed that there is an equivalence in kind. That is, erythema, tumor regression, and a host of other biological effects, are all produced by radiation of widely different wave lengths, irrespective of any possible dif-

ferences in the mechanism by which these biological changes are brought about.

The biological dose, D_b , may be expressed as follows

$$D_b = D q b,$$

where D = Dose, or quantity factor, which can be measured and expressed in suitable units

q = Quality factor, representing the biological effectiveness of radiation with respect to wave length

b is a factor depending on all other conditions—largely biological—which are assumed to remain constant, when the influence of wave length is being investigated (Therefore it can be taken as unity in the present case.)

We shall now inquire how the dose D should be measured and in what unit it should be expressed in order that the quality factor q shall depend only on the wave length of the radiation, as it should when all other conditions are constant. It has been stated many times, and it is obvious, that the part of the radiation which is responsible for the biological effect is that which is "absorbed" by the living organism. In the case of ionizing radiation, not all the absorbed energy manifests itself in the form of ionization, but the ratio between the total absorbed energy and that which is utilized in forming ions is, so far as we know, substantially independent of the wave length, in the present therapeutic range. Thus, since the two are related by a proportionality factor, one may take ionization as a measure of energy absorbed. This refers, of course, to the ionization produced in the living material, at the point where the biological change takes place. Since the number of electrolytic ions pres-

ent in the material is very much larger than the number of radio-ions which may be set free by a therapeutic dose of radiation, it is practically impossible to measure directly the radiation ionization. This difficulty may be overcome provided we can measure something which is related by a simple proportionality factor to tissue ionization at the point in question. Since ionization in gases may be measured very readily, it would be very convenient to take advantage of this. We shall inquire, therefore, under what conditions the ionization in a gas may be expected to be proportional to that in living tissue.

The interaction of radiation and matter depends on the number of electrons in the material, and on the atomic numbers of its constituent chemical elements. Therefore, the energy absorbed from a beam of radiation per gram of tissue is the same as that which would be absorbed per gram of a gas containing the same chemical elements in the same proportions, under comparable conditions. The number of ions would not be the same since it depends also on the chemical state of the matter, but the proportionality factor would remain constant throughout the wave length range used in therapy. There are two different mechanisms by which radiation transfers energy to matter, although in both cases the transfer occurs by setting electrons in motion. In the photoelectric process, the controlling factor is the atomic number of each chemical element in the material, whereas in the Compton process the controlling factor is the total number of electrons present. Whether one or the other predominates, depends on the wave length of the radiation. For γ -rays produced at voltages higher than 150 or 200 kv, and matter composed of low atomic number elements (such as living tissue) photoelectric absorption is negligible. Accordingly in this case the proportionality between ionization in tissues and in a gas may be expressed with sufficient constancy with respect to wave length for practical purposes, even when the chemical composition of the gas is not exactly the same as that of the

tissue in which the biological effect is produced. Air, being composed largely of nitrogen and oxygen, is probably a satisfactory gas to use in this range of wave lengths.

In recapitulation, we may say that in the wave length range of filtered 150 to 200 kv γ -rays and gamma rays, we may expect reasonably constant proportionality factors between (1) ionization in air and ionization in tissues, (2) ionization and energy absorbed in tissues, and consequently (3) ionization in air and energy absorbed in tissues, provided the ionization in air is produced under conditions comparable to those obtaining in the irradiated tissue. Hence, since absorbed energy must be considered as the ultimate cause of the biological change, air ionization will bear the same relation thereto. Thus the simplest correlation between cause and effect may well be expected by using air ionization (under suitable conditions) to represent the cause, namely the dose of radiation. In the case of soft γ -rays, air is not a suitable gas because of the difference in atomic numbers of its constituents (nitrogen 79 per cent, oxygen 21 per cent) and those of tissue (roughly oxygen 65 per cent, carbon 18 per cent, hydrogen 10 per cent, nitrogen 3 per cent). Furthermore, the influence of the small proportions of elements of higher atomic number, (calcium, phosphorus, potassium, sodium, etc.) present in tissues but absent in air, is probably considerable in the range of soft γ -rays.¹

The requirement that the ionization in the gas (air), which is to be taken as a measure of dose, must be produced under the same conditions as those obtaining in the living material during the irradiation, at the point where the biological effect is produced, has been emphasized already. It is the main purpose of this paper to describe methods and means by which this requirement may be met satisfactorily in all cases of practical importance, insofar as our present knowledge permits.

¹ This problem is being investigated experimentally in our laboratory by Dr. R. Naidu, of the Tata Memorial Hospital, Bombay, India.

A knowledge of the "skin dose" in radiation therapy is of paramount importance, since, in general, it is skin damage which limits the amount of radiation that may be delivered to a deep-seated tumor. Where the seat of the skin injury is, or what particular layer of the skin is most vulnerable, is of no concern in the present discussion. It is obvious, however, that in order to study the reaction of the skin to radiation, it is essential to know the energy absorbed by different layers of the skin, and, perhaps, the subcutaneous tissues. In the range of ordinary x-rays and gamma rays we may take ionization in air as a measure of energy absorbed in an equal mass of tissue. How shall we determine the air ionization at different levels in the skin, including the surface? It is evident *a priori* that the desired information cannot be obtained directly by the use of the well-known thimble chamber, for such a chamber is necessarily too large in comparison to the thickness of human skin. Both the air space and the solid walls of the chamber disturb the physical conditions which influence the ionization at the surface of the skin, even when the chamber is of the so-called air wall type. Two absurd requirements should be met by an ionization chamber suitable for this purpose: (1) it should have no walls, and (2) it should have no air volume. Surprising as it may seem to the uninitiated, these conditions can actually be fulfilled in practice. The general method is as follows. For the surface dose we wish to determine the ionization in a vanishingly thin layer of air in actual contact with the skin, in order that the back-scattered radiation may be properly evaluated. There must not be anything in the path of the incoming radiation which is not present during the treatment. Let us take a hypothetical ionization chamber with two walls, each one square centimeter in area, separated by an air space one millimeter thick. We place the chamber on the surface of the skin at the point where the ionization is to be determined and we take a reading. We then decrease the thickness of the chamber walls by some means or

other and take another reading under the same conditions. We repeat the process until the walls are as thin as they can be made. From these readings we obtain a curve which shows the variation of the ionization in the chamber with wall thickness. The curve is then prolonged—extrapolated—to zero wall thickness and the value of the ionization which would be obtained in the same chamber with vanishingly thin walls, can be read on the ionization reading scale.

We have assumed the thickness of the air layer in the hypothetical chamber to be one millimeter. In order to reduce this to the vanishing point, we may make use of an extrapolation method similar to the one just described. Maintaining the wall thickness constant and at its lowest practical value, readings are taken with air layers of different thicknesses, down to a minimum which is set by instrumental limitations. It is evident that the larger the air thickness the larger the ionization reading, and that when the air thickness is zero, the reading must also be zero. On the other hand, the ionization per unit volume of air has a definite value even when the air space is vanishingly small. From the actual ionization readings we derive the values of the ionization per cubic centimeter of air. Plotting these, we obtain the relation between air layer thickness and ionization per cubic centimeter. Extrapolating the curve to zero air thickness, one obtains the ionization per cubic centimeter which would be produced in a chamber having very thin walls and a vanishingly small air thickness, placed at the surface of the skin. By means of the wall thickness curve previously obtained, one can correct this value for the thickness of the chamber wall, and the result will represent the ionization per cubic centimeter of air at the very surface of the skin, under the conditions in which the skin is irradiated.

Nothing has been said about the nature of the chamber walls, and it may be assumed that, since the influence of the wall thickness is eliminated by extrapolation, the material of which it is made plays no

part in the final results. However, the ionization produced in the thin air layer is due almost entirely to electrons which

circle 2.96 cm in diameter was scribed at the center. The inked surface within the circle constitutes the collecting electrode,

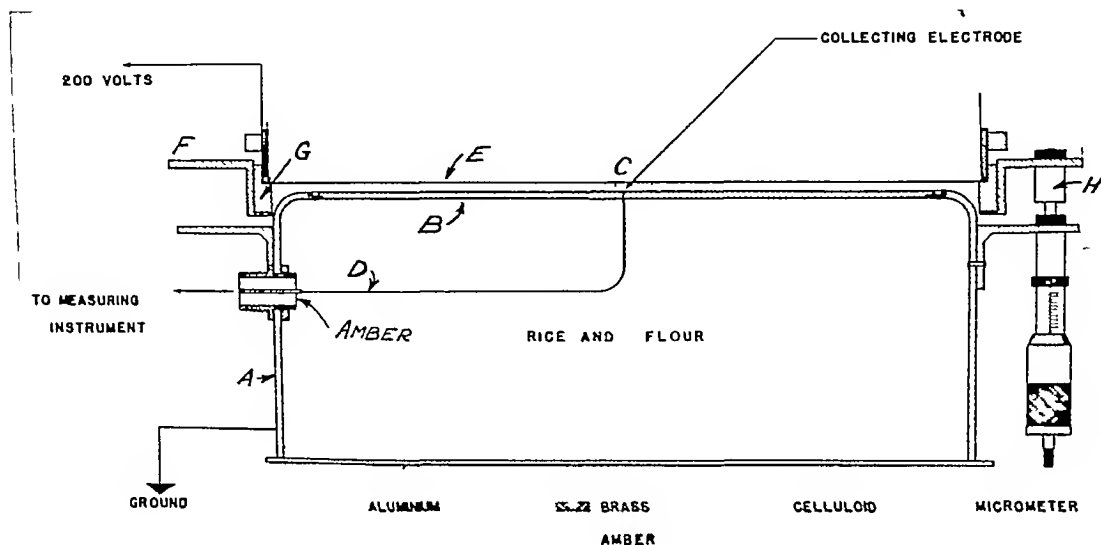


Fig 1 Extrapolation ionization chamber for the measurement of tissue doses in roentgen and telecurie therapy

either originate in the walls or reach the air volume by penetrating through them. Hence the experimental readings are influenced markedly by the material of which the chamber is made. The reasons for the use of air equivalent materials in the construction of thimble chambers are well known. They apply equally to the present case. In general it is even better to have tissue equivalent materials.² The hypothetical ionization chamber considered so far is not practical. The construction of a suitable one involves many difficulties and much time was spent by us before a satisfactory solution was obtained. The one which has been used in our laboratory during the past year is shown in Figure 1. An aluminum pot, A, about 30 cm in diameter and 15 cm deep, was used as the foundation. The bottom of the pot was turned out and a celluloid disk, B, 3 mm thick, was screwed on in its place. The top of the celluloid disk was coated with India ink, and by means of a sharp compass a

while the outer surface which is conductively connected to the aluminum pot, serves the purpose of a guard ring and helps provide a uniform electrostatic field over the entire area of the collecting electrode. When a null method of measurement is used, a very narrow and superficial scratch made with the compass is sufficient to provide good insulation between the collecting electrode and the adjoining conducting surface. Thus very little field distortion occurs at the boundary of the collecting electrode, and its effective area may be calculated from the diameter of the circle passing through the center of the insulating gap. The collecting electrode is connected to the current measuring instrument through a very fine rubber insulated wire D.³ The wire does not extend

³ This connection gave us considerable trouble and several schemes have been tried. The details of the one used finally have been forgotten. It may be useful to mention that at first we tried to make the connection between the collecting electrode and the amber bushing by running a fine aluminum wire in a slot in the celluloid disk. The slot was filled with paraffin. For some unaccountable reason—which we did not spend time to investigate—this collecting electrode system acted as if it were the pole of a battery and supplied current

² This is imperative when the ionization to be measured is produced by the passage of neutrons through tissue.

to the surface of the collecting electrode, but good electrical contact is effected by carbon. The lower side of the celluloid disk, *B*, was also coated with ink, except for a small space around the wire connection. The space below the electrode was filled with rice and flour to provide a convenient substitute for tissue.

The upper electrode was made in such a way that it could be changed readily without disturbing the set-up appreciably. The thinnest one consisted of ink-soaked silk chiffon, stretched over an aluminium hoop about 30 cm in diameter. The mass per square centimeter of this material is 20 mg, which corresponds to a thickness of 0.02 mm, assuming a density of one gram per cubic centimeter. Similar but thicker upper electrodes were made of parchment, and of "Masonite pressed-wood," the latter being used for thicknesses greater than three millimeters. This material is readily obtainable at low cost in sheets of two or three different thicknesses. It consists largely of wood pulp, has a density of 1.01 gram per c.c. and an ash residue of 1.67 mg per c.c., not unlike that of soft tissues.

In order to provide simple and precise adjustment of the spacing between electrodes, three micrometer screws were mounted as the one shown in the figure. The lower aluminium ring on which the micrometers are rigidly mounted, was fitted to the aluminium pot and its surfaces were machined at the same time that the recess for the celluloid disk was turned out in the lathe, thus insuring parallelism be-

tween the two. The aluminium ring, *F*, was machined a second time after the celluloid ring, *G*, had been fastened to it, to make sure that the plane of the recess into which fits the upper electrode was parallel to the plane of the ring. The celluloid ring serves to insulate the charged upper electrode from the earthed aluminium parts. Three carefully adjusted steel anvils, *H*, rigidly fastened to the ring, *F*, register with the appropriate micrometers, so that when their readings are the same, the two electrodes are parallel to each other.⁴ Proper registration of anvils and micrometer screws is maintained by three guides not shown in the figure.

A null method of measuring the ionization current is always used. The collecting electrode is maintained at earth potential, which is also the potential of the guard ring. Thus there is no leakage to take into account, and the electrostatic field between the electrodes is perpendicular thereto and uniform. In this way the air volume in which the ionization is measured is determined by the area of the collecting electrode and the distance between electrodes. With the silk chiffon electrode in place, practically all the incoming radiation and its secondary electrons can reach the air volume. The influence of even this thin layer of matter can be eliminated by extrapolation, as already described. When the spacing is very small and the beam larger than the collecting electrode (which, of course, should always be the case) the air volume receives the appropriate quota of the back-scattered radiation. However, there are certain things which should be examined critically. Is the back-scattered radiation in this chamber, with its 3 mm celluloid electrode and the rice and flour backing, the same as it would be from a mass of tissue of equal mass and shape? This depends on the type and quality of the radiation considered. For ordinary γ -rays

⁴ We have found in actual use that the celluloid disk does not remain plane and it is very difficult to determine the absolute spacing with great precision. The relative spacing can be determined very accurately from the micrometer readings and this is sufficient for most practical purposes.

of relatively large magnitude to the measuring instrument for long periods of time. The paraffin by itself could not have been responsible for the effect, since in another chamber of this type in which the wire was embedded in a block of paraffin used for months before the present chamber was constructed no such effect was present at any time. Recently through the courtesy of the Plastics Department of E. I. du Pont de Nemours and Company we have obtained an electrode in which a very fine piano wire is embedded between two thin sheets of Lucite composited into one solid sheet under high pressure and appropriate temperature. A similar electrode made of Styrol is also available. Lack of time has prevented a study of these electrodes.

and gamma rays the difference is negligible within the limits of experimental error in biological investigations. We have thought that the difference in chemical composition and density between celluloid and tissue may cause a slight error. Inasmuch as the contribution to the measured ionization of the back-scattered radiation is due almost entirely to secondary electrons which leave the surface of the lower electrode, we have thought that the ink coating (carbon) may provide a lower quota than the skin would when the radiation is very soft. These points, which are probably of little importance in the present practical range of therapeutic radiation are being investigated. It is hardly necessary to point out that the shape and size of the scattering material (rice and flour in this case) should be the same as the part of the body for which the skin dose is desired. The present chamber was constructed primarily for the purpose of comparing surface and depth doses measured under the same conditions by this method and by the usual thimble chamber method. Chambers of more general applicability are in the course of construction.

We have indicated how the ionization in air at the very surface of the skin can be determined. The ionization in a vanishingly thin layer of air at any skin or tissue depth can be determined in an analogous way, except that in this case only extrapolation to zero air thickness is necessary. By using for the upper electrode sheets of parchment or other suitable material, of appropriate density and thickness, it is a simple matter to determine the air ionization which corresponds to different depths in the skin and subcutaneous tissues.

A great deal of work has been done with chambers of this type in our laboratory by Mrs. Edith H. Quimby, Mr. L. D. Marinelli, and others, who will publish the results in the near future. At this time we shall discuss only the correlation of ionization measured by this method and skin erythema, in order to bring out an important point in the problem of choosing a unit of dose. Measurement of the air ionization at the surface and at different depths

have been made with this chamber under comparable conditions, using three widely different qualities of radiation: (1) soft x-rays, produced at 85 kv, filtered by 1 mm of aluminum, having a half value layer of 1.7 mm of aluminum, (2) hard x-rays, produced at 200 kv, filtered by 0.5 mm of copper and 2.5 mm of aluminum, having a half value layer of 1 mm of copper, (3) gamma rays from a four-gram radium bomb with an estimated metallic filter equivalent to 2 mm of lead, and a secondary filter of 3 mm of celluloid (which in the erythema tests was in contact with the skin). Previous experiments had shown that in the case of x-rays, extrapolation to zero thickness of upper electrode was unnecessary. Accordingly, only the 0.18 mm parchment electrode was used. In the case of gamma rays, the upper electrode was a sheet of celluloid 3 mm thick, corresponding to the celluloid filter used in contact with the skin in the erythema determinations. Extrapolation to zero air thickness was carried out in all three cases. The only appreciable difference in the conditions under which the ionization measurements and the erythema tests, respectively, were carried out, resides in the much larger volume of scattering material (rice and flour) in the chamber as compared to the human forearm. However in all cases the measurements were made with radiation fields of the same (small) size as used in the erythema tests. The possible error caused by this difference does not alter the general conclusions, and may be ignored for the present. The ionization doses of the three qualities of radiation required to produce the threshold erythema⁵ on the forearm of the average white adult are 0.36×10^{14} , 1.05×10^{14} , and 1.75×10^{14} ion pairs per gram of air, respectively, for soft x-rays, hard x-rays, and gamma rays. These figures refer to the ionization produced at the very surface of the skin. It is important to note that the relative values remain essentially the same no matter what depth within the skin is chosen for the seat of the

⁵ When the radiation is administered continuously during a period not exceeding about two hours.

to the surface of the collecting electrode, but good electrical contact is effected by carbon. The lower side of the celluloid disk, *B*, was also coated with ink, except for a small space around the wire connection. The space below the electrode was filled with rice and flour to provide a convenient substitute for tissue.

The upper electrode was made in such a way that it could be changed readily without disturbing the set-up appreciably. The thinnest one consisted of ink-soaked silk chiffon, stretched over an aluminum hoop about 30 cm in diameter. The mass per square centimeter of this material is 20 mg, which corresponds to a thickness of 0.02 mm, assuming a density of one gram per cubic centimeter. Similar but thicker upper electrodes were made of parchment, and of "Masonite pressed-wood," the latter being used for thicknesses greater than three millimeters. This material is readily obtainable at low cost in sheets of two or three different thicknesses. It consists largely of wood pulp, has a density of 1.01 gram per c.c. and an ash residue of 1.67 mg per c.c., not unlike that of soft tissues.

In order to provide simple and precise adjustment of the spacing between electrodes, three micrometer screws were mounted as the one shown in the figure. The lower aluminum ring on which the micrometers are rigidly mounted, was fitted to the aluminum pot and its surfaces were machined at the same time that the recess for the celluloid disk was turned out in the lathe, thus insuring parallelism be-

tween the two. The aluminum ring, *F*, was machined a second time after the celluloid ring, *G*, had been fastened to it, to make sure that the plane of the recess into which fits the upper electrode was parallel to the plane of the ring. The celluloid ring serves to insulate the charged upper electrode from the earthed aluminum parts. Three carefully adjusted steel anvils, *H*, rigidly fastened to the ring, *F*, register with the appropriate micrometers, so that when their readings are the same, the two electrodes are parallel to each other.⁴ Proper registration of anvils and micrometer screws is maintained by three guides not shown in the figure.

A null method of measuring the ionization current is always used. The collecting electrode is maintained at earth potential, which is also the potential of the guard ring. Thus there is no leakage to take into account, and the electrostatic field between the electrodes is perpendicular thereto and uniform. In this way the air volume in which the ionization is measured is determined by the area of the collecting electrode and the distance between electrodes. With the silk chiffon electrode in place, practically all the incoming radiation and its secondary electrons can reach the air volume. The influence of even this thin layer of matter can be eliminated by extrapolation, as already described. When the spacing is very small and the beam larger than the collecting electrode (which, of course, should always be the case) the air volume receives the appropriate quota of the back-scattered radiation. However, there are certain things which should be examined critically. Is the back-scattered radiation in this chamber, with its 3 mm celluloid electrode and the rice and flour backing, the same as it would be from a mass of tissue of equal mass and shape? This depends on the type and quality of the radiation considered. For ordinary x-rays

of relatively large magnitude to the measuring instrument for long periods of time. The paraffin by itself could not have been responsible for the effect, since in another chamber of this type in which the wire was embedded in a block of paraffin used for months before the present chamber was constructed no such effect was present at any time. Recently through the courtesy of the Plastics Department of E. I. du Pont de Nemours and Company we have obtained an electrode in which a very fine piano wire is embedded between two thin sheets of Lucite composited into one solid sheet under high pressure and appropriate temperature. A similar electrode made of Styrol¹ is also available. Lack of time has prevented a study of these electrodes.

⁴ We have found in actual use that the celluloid disk does not remain plane and it is very difficult to determine the absolute spacing with great precision. The relative spacing can be determined very accurately from the micrometer readings and this is sufficient for most practical purposes.

purpose for which it was originally intended, although strictly speaking, the wording of the definition of the unit does not justify this use. For the moment we need not insist on this point. The obvious fact is that the skin dose must include the contribution due to the back-scattered radiation. Since no unit of "tissue dose" has been adopted, the roentgen is generally used for this purpose as well, explicitly or implicitly. Following the usual procedure, therefore, we shall determine the surface doses for the three qualities of radiation, by means of suitable thimble chambers "half submerged" in the tissue substitute (water or pressdwood).

It so happens that in the quality range of ordinary x-rays, measurements of *surface dose* with the thimble chamber we used are in reasonably good agreement with the corresponding extrapolation chamber measurements. In the case of gamma rays, however, there is a large discrepancy. The details of the measurements are as follows. In order to make sure that the gamma rays reaching the skin in the erythema tests did not contain spurious secondary electrons, a sheet of celluloid 3 mm thick was placed on top of the skin, and the four-gram radium pack was brought in contact with the celluloid also. Under these conditions the skin was at a distance of 6.3 cm from the radium. The extrapolation chamber measurements were made with an upper electrode of the same material and thickness (3 mm celluloid), the only difference being that in this case the celluloid was coated with ink. Readings were taken with different electrode spacings and by extrapolation was obtained the value of the ionization per cubic centimeter in a vanishingly thin air space between the celluloid electrodes at the 6.3 cm distance. The measurements with the thimble chamber could not be made at the same distance, since the celluloid secondary filter was in the way. Readings were taken, however, with the chamber touching the celluloid sheet and at greater distances. From the curve thus obtained, the reading at 6.3 cm distance was determined with con-

siderable precision. We have made similar measurements on numerous occasions, with and without back-scatter. With the chamber half submerged in a tank of water, the back-scatter amounts to 11 per cent. The thimble chamber is spherical, with an inside diameter of 1.52 cm, and a celluloid wall 1.4 mm thick. The stem through which connection to the measuring instrument is made, is about 7 mm in diameter. Objections may be raised to the use of this chamber for gamma-ray measurements on the ground of insufficient wall thickness. We know, however, that a thicker wall would not alter the result appreciably in this case.⁸ Accordingly, we may take for granted that the measurements with the thimble chamber were made under conditions which are very nearly those recommended by several investigators for the measurement of gamma rays *in roentgens*. The effective radiation intensity at the 6.3 cm distance determined in this manner by the thimble chamber was found to be 12.3 r per minute, including the back-scattered radiation from a large tank of water. On the other hand, the corresponding value obtained with the extrapolation chamber was 9 e.s.u. per c.c. per min. If the conditions under which the ionization was produced in the air volume of the extrapolation chamber meet the requirements set forth by the proponents of the thimble chamber method for measuring gamma rays in roentgens, 9 e.s.u. per c.c. per min are equivalent to 9 r per min. Since the two methods of measurement give values of presumably the same quantity, which differ considerably, one or the other or both methods must be incorrect.

L. H. Gray's work (1, 2) has been quoted repeatedly in support of the thesis that a small thimble chamber with "air walls" three or four millimeters thick measures gamma rays in roentgens. We see no reason why this should not be so, but at the same time we see no reason why the con-

⁸ At any rate, those who might raise the objection would expect the reading with this chamber to be too low. As a matter of fact it is already much higher than that obtained with the extrapolation chamber (*infra*).

biological reaction. If it is assumed that the threshold erythema is one manifestation of the changes which take place in all underlying tissues, the difference between the ionization doses for 85 kv and 200 kv x-rays, will be still greater, since under the conditions of the experiments the decrease in radiation intensity with depth was greater in the case of the softer x-rays. Assuming that the dose is properly measured by the method described here, it is evident that the same dose of radiation does not produce the same biological effect (threshold erythema) when the quality of radiation is different. Except for minor refinements we can find nothing which might vitiate the general results.

The main point we wish to bring out in this connection is not the wave length dependence of skin erythema, but the simplification which may be brought about by the choice of a suitable unit of dosage. If we agree by definition that the biological dose of radiation is the same irrespective of quality, provided all other conditions remain constant, we have for the threshold skin erythema

$$0.36 \times 10^{12} \times q_{85} = 1.05 \times 10^{12} \times q_{200} = 1.75 \times 10^{12} \times q_r$$

Thus the relative values of the quality factor q in this case are

$$\text{For 85 kv x-rays, H V L 1.7 mm Al, } q_{85} = 2.9$$

$$\text{For 200 kv x-rays, H V L 1 mm Cu, } q_{200} = 1$$

$$\text{For filtered gamma rays } q_r = 0.6$$

assigning the value 1 to the quality factor for 200 kv x-rays. This means that a dose of 85 kv x-rays, of 1.7 mm Al H V L, is 4.8 times smaller than the dose of gamma rays is necessary to produce the threshold erythema.⁶ Similarly, in the case of 200 kv x-rays of 1 mm Cu H V L, the threshold erythema dose is 1.7 times smaller than for

gamma rays. The quality factor, therefore, furnishes an index of the biological effectiveness of radiation of different wave lengths for a particular effect produced under comparable conditions. A knowledge of this factor is essential for proper dosage in radiation therapy, but unfortunately the relative numerical values of the factor can be obtained only through extensive experimentation (both physical and biological).

Ionization doses in the illustrative case just discussed were expressed in terms of the number of ion pairs produced per gram of air. It is important to consider now how measurements made in roentgens can be utilized for this purpose. The method of measuring skin dose, which we have described, can hardly be contested, although there may be some differences of opinion concerning details of the apparatus or the depth in the skin at which the measurements should be made. Therefore, it is reasonable to assume that skin doses measured in this way are very nearly correct, the criterion of correctness being the measurement of something which is related to the immediate cause of the biological effect (i.e., energy absorbed by the tissue) by a constant proportionality factor. In practice, an x-ray machine in the radiological clinic is calibrated by means of a suitable thimble chamber, and the radiation output at a certain point in the beam, under given conditions, is expressed in roentgens per minute. The radiologist then places a patient with a part of his skin at the same point in the radiation beam. What is the skin dose delivered in a certain treatment, and in what unit can it be expressed? The usual procedure⁷ is to multiply by the appropriate backscatter factor and the time in minutes the r per minute value obtained from the measurement with the thimble chamber suspended in air, and to call the product the number of roentgens which the skin receives, that is, the skin dose. In so doing, the radiologist uses the roentgen for the

⁶ It should not be assumed that the ratio is the same for all biological effects. It is definitely known that this is not the case. (Cf. Failla and Marinelli's paper on gamma ray measurements in the August 1937 number of the 'American Journal of Roentgenology and Radium Therapy'.)

⁷ Some prefer to make the thimble chamber measurement on the skin of the patient. This is immaterial.

x-rays are the same as before, because measurements of surface dose by the extrapolation and thimble chamber methods are

Hence, if the surface dose of gamma rays is measured in roentgens by a thimble chamber, we have

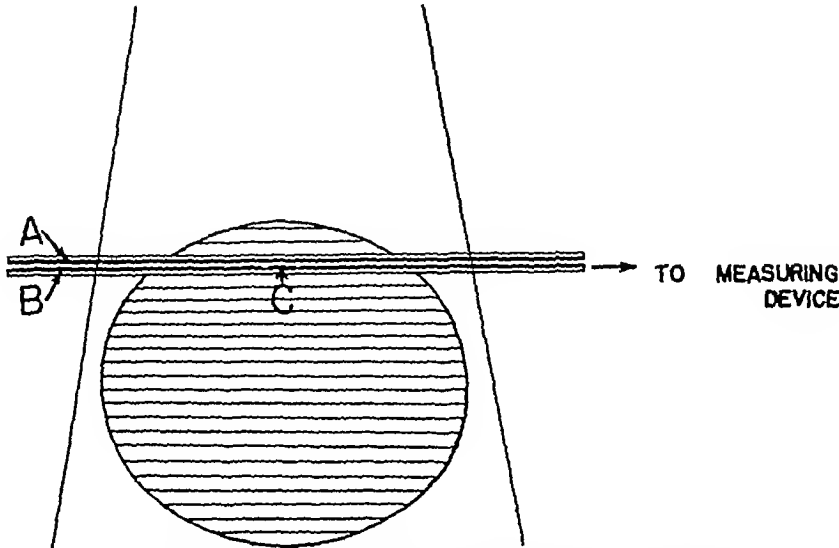
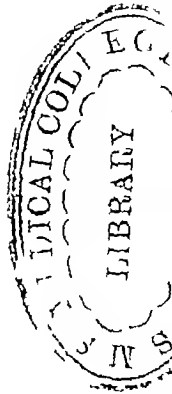


Fig 2 Modification of extrapolation ionization chamber for the measurement of depth doses in a laminated phantom of the same shape and size as a given part of the human body



in good agreement in this quality range. The values for gamma rays are quite different, which means that both cannot be correct. If the extrapolation chamber measures the surface ionization dose of rays correctly, it is necessary to reduce the reading obtained with the thimble chamber to that of the extrapolation chamber, in order to make the proper correlation between dose and biological effect. This can be done by introducing a correction factor f which can be determined by experiment. In the case under consideration the surface dose of gamma rays required to produce the threshold erythema is 1,490 r, assuming that the thimble chamber measures gamma rays in roentgens, and that it is proper to use this unit in cases where the back-scattered radiation is included. This is equivalent to $1,490 \times 1.62 \times 10^{12} = 2.41 \times 10^{15}$ ion pairs per gram of air. The corresponding quantity obtained with the extrapolation chamber is 1.75×10^{15} ion pairs per gram, and therefore the correction factor is

$$f = \frac{1.75 \times 10^{15}}{2.41 \times 10^{15}} = 0.73$$

$$D_b = D q = D_r f q,$$

in which D is now expressed in a unit representing the same number of ion pairs per gram of air as the roentgen (1.62×10^{12}). D may well be called the "tissue dose" and the unit the "tissue roentgen". It should be noted that the roentgen and the tissue roentgen have only one thing in common, namely, the number of ion pairs per gram of air. The conditions under which quantities of radiation must be measured in order to be expressed in roentgens, are set forth in the definition of the unit. The conditions under which quantities of radiation must be measured in order to determine the tissue dose are those which obtain in the biological material, during the irradiation, at the point where the biological effect is produced. They can then be expressed in "tissue roentgens".

Having presented the general method of attack somewhat in detail, it suffices to outline the necessary special procedures to be followed in special cases. In Figure 2 is shown schematically the case in which we wish to determine the tissue doses at different levels in a mass of tissue of the cross-

ditions obtaining in the air volume of the extrapolation chamber do not meet the requirements set forth by Gray Mayneord (3) in his recent precision measurements of gamma rays used a cylindrical thimble chamber 2 cm in diameter and 2 cm long (inside dimensions). The diameter of the collecting electrode in the extrapolation chamber, 2.96 cm, is not much larger. Therefore the maximum linear dimension of the "air cavity" in our case cannot be said to be too large. The other dimension (height of cylinder) was always much smaller than in Mayneord's case, 0.5 to several millimeters. The air volume in the extrapolation chamber is at the center and between two disks of celluloid 30 cm in diameter and 3 mm thick. When the spacing is 0.5 mm, is it not reasonable to assume that the ionization is measured in an air cavity effectively surrounded by celluloid? Furthermore, by extrapolation we should obtain the value of the ionization per c.c. with the celluloid plates (almost) in contact, in which case it would be hypercritical to say that the air volume was not completely surrounded by celluloid. We do not wish to take a definite stand on this matter at this time, but it is obvious that further investigation of the problem in different laboratories is highly desirable before a generally acceptable conclusion may be reached. However, the following considerations may provide a clue.

The ionization produced in a thick-walled thimble chamber is almost entirely due to electrons originating in the walls. The latter may be divided into (1) front wall, (2) side walls, and (3) back wall. The contribution of each may be ascertained by suitable experiments. It is found then that quite a high percentage of the ionization is due to the presence of thick side walls. In view of the fact that the ejection of recoil electrons is predominantly in the forward direction, it would appear that better relative utilization of those originating in the side walls will result when the latter are long. Most of the experimenters who have worked on the problem of measuring gamma rays in roentgens have used thimble

chambers in which the three linear dimensions have not differed greatly. Accordingly the contribution of the side walls has been considerable. In the case of the extrapolation chamber, the height of the cylindrical air volume is very small in comparison to the diameter, and besides there is no side wall. Nevertheless, as already pointed out, when the air layer is vanishingly thin, the volume in which the ionization is measured may well be considered to be completely surrounded by celluloid. The problem then resolves itself as to whether the presence of thick side walls in the ordinary thimble chamber causes an excessive contribution of electrons to the enclosed air volume. This point deserves careful study.

Returning to the problem of expressing the biological dose for the threshold erythema reaction produced by the three qualities of radiation, in terms of thimble chamber measurements in all three cases, we find

$$D_b = Dq = 225 \times q_{85} = 650 \times q_{200} = 1490 \times q$$

in which D is expressed in roentgens, with approximate allowance for backscatter. Whence, taking $q_{200} = 1$, as before, the relative values of q are

For 85 kv x-rays, H.V.L. 1.7 mm Al,
 $q_{85} = 2.90$,

For 200 kv x-rays, H.V.L. 1 mm Cu,
 $q_{200} = 1$,

For filtered gamma rays,
 $q = 0.44$

Since q represents the biological effectiveness of radiation with respect to quality, it is evident that the threshold erythema is not independent of wave length. This conclusion is in accord with the one arrived at previously in the case of measurements of the ionization dose by means of the extrapolation chamber. That the same general conclusion should be reached is obvious when one considers that the relative biological effectiveness of radiation of different wave lengths is dependent on biological factors which play no part in the measurement of the dose by physical means. The values of q for soft and hard

x-rays are the same as before, because measurements of surface dose by the extrapolation and thimble chamber methods are

Hence, if the surface dose of gamma rays is measured in roentgens by a thimble chamber, we have

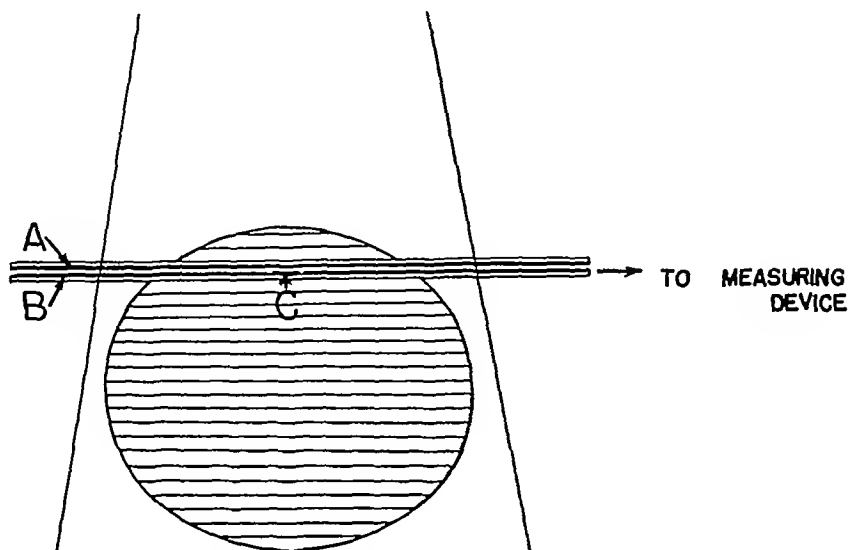


Fig 2 Modification of extrapolation ionization chamber for the measurement of depth doses in a laminated phantom of the same shape and size as a given part of the human body

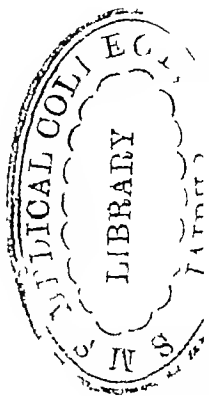
in good agreement in this quality range. The values for gamma rays are quite different, which means that both cannot be correct. If the extrapolation chamber measures the surface ionization dose of rays correctly, it is necessary to reduce the reading obtained with the thimble chamber to that of the extrapolation chamber, in order to make the proper correlation between dose and biological effect. This can be done by introducing a correction factor f which can be determined by experiment. In the case under consideration the surface dose of gamma rays required to produce the threshold erythema is 1,490 r, assuming that the thimble chamber measures gamma rays in roentgens, and that it is proper to use this unit in cases where the back-scattered radiation is included. This is equivalent to $1,490 \times 1.62 \times 10^{12} = 2.41 \times 10^{15}$ ion pairs per gram of air. The corresponding quantity obtained with the extrapolation chamber is 1.75×10^{15} ion pairs per gram, and therefore the correction factor is

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$$D_b = D q = D_r f q,$$

in which D is now expressed in a unit representing the same number of ion pairs per gram of air as the roentgen (1.62×10^{12}). D may well be called the "tissue dose" and the unit the "tissue roentgen". It should be noted that the roentgen and the tissue roentgen have only one thing in common, namely, the number of ion pairs per gram of air. The conditions under which quantities of radiation must be measured in order to be expressed in roentgens, are set forth in the definition of the unit. The conditions under which quantities of radiation must be measured in order to determine the tissue dose are those which obtain in the biological material, during the irradiation, at the point where the biological effect is produced. They can then be expressed in "tissue roentgens".

Having presented the general method of attack somewhat in detail, it suffices to outline the necessary special procedures to be followed in special cases. In Figure 2 is shown schematically the case in which we wish to determine the tissue doses at different levels in a mass of tissue of the cross-



section shown. It is convenient to have the plate of the extrapolation chamber which carries the collecting electrode in one unit, with the wire connecting the electrode to the current measuring device properly insulated and shielded within the plate itself. The plate should be of organic material of approximately unit specific gravity, and should be a good electrical insulator. It should be thin. (The "Lucite" and "Styrol" electrodes mentioned previously fulfil these requirements, but since they have not been tested, we cannot say as yet that they are satisfactory.) The design of the upper electrode depends on whether surface or depth dose is to be determined. In the latter case, extrapolation to zero air space is all that is necessary, and the initial thickness of the upper electrode is not important. In the figure, fairly thick electrodes are shown. As a first approximation, the part of the body in which the depth doses are to be measured may be reproduced in shape and volume by slabs of pressedwood, as shown. Measurements at different levels can then be made by placing the proper number of slabs above and below the chamber. Extrapolation to zero air space is not always necessary, but this should be determined by experiment. If greater accuracy is desired it is necessary to reproduce in the phantom bones, air cavities, differences in tissue densities, etc., as they are in the part of the body under consideration. It is possible, but not very convenient, to use slabs of tissue from a frozen cadaver.

The extrapolation chamber of the type described so far is useful for measurements applicable to x-ray and telecurie therapy. In radium therapy the source is more often placed in body cavities or within the pathological tissues. In such cases the therapeutic effect is expected in the immediate vicinity of the source, and it is necessary to determine the dose at short distances therefrom. In Figure 3 is indicated the extrapolation method applicable to the case of a radium needle. A thin celluloid test tube, *T*, forms the inner electrode of the chamber. After coating its (outer) surface with

India ink or "aequadag," two very narrow grooves are scratched in it with a sharp tool in the lathe. Thus a narrow band of the conducting surface is insulated from the rest, and forms the collecting electrode, *C*, which is connected to the measuring device through the wire, *W*. A second thin celluloid test tube of larger diameter than the first is coated with ink on the inside and forms the outer electrode, *O*. The two electrodes are mounted concentrically by means of the insulating rings, *I*. The conducting surfaces of the inner cylinder adjacent to the collecting electrode are connected to earth as shown, and serve the purpose of guard rings as well as that of providing a radial electric field. The volume in which the ionization is measured is determined by the area of the collecting electrode and the thickness of the air space between the test tubes. The radium needle, *Ra*, is placed in a narrow celluloid tube, *A*, attached to the smaller test tube as shown. The needle can be moved up or down depending on the longitudinal position at which the ionization is to be determined. Through tube *A*, filled with water, contact is made with the lower guard ring by means of the conductor *G*. The water and ground connection in this case also serve the purpose of removing any charge which might accumulate on the needle on account of the emission of primary or secondary electrons. Water (or water and ground tissue, if desired) is placed in the inner test tube and around the outer test tube, to provide the proper absorbing and scattering conditions. Extrapolation to zero air space is carried out by using outer electrodes of different diameters. It is desirable to obtain readings with very thin air layers since the inverse square law in this case has considerable influence. We have not made measurements with a chamber just as described here. However, with similar ones we have found an appreciable difference in the ionization current according to whether the outer electrode was charged positively or negatively. The difference is due to the excess of electrons leaving the collecting electrode. This

effect must be taken into account in determining the ionization in the (narrow) air space. The correct value of the ioniza-

the distribution of radiation around the source by this method, but we have made exploratory tests and we are sure that no

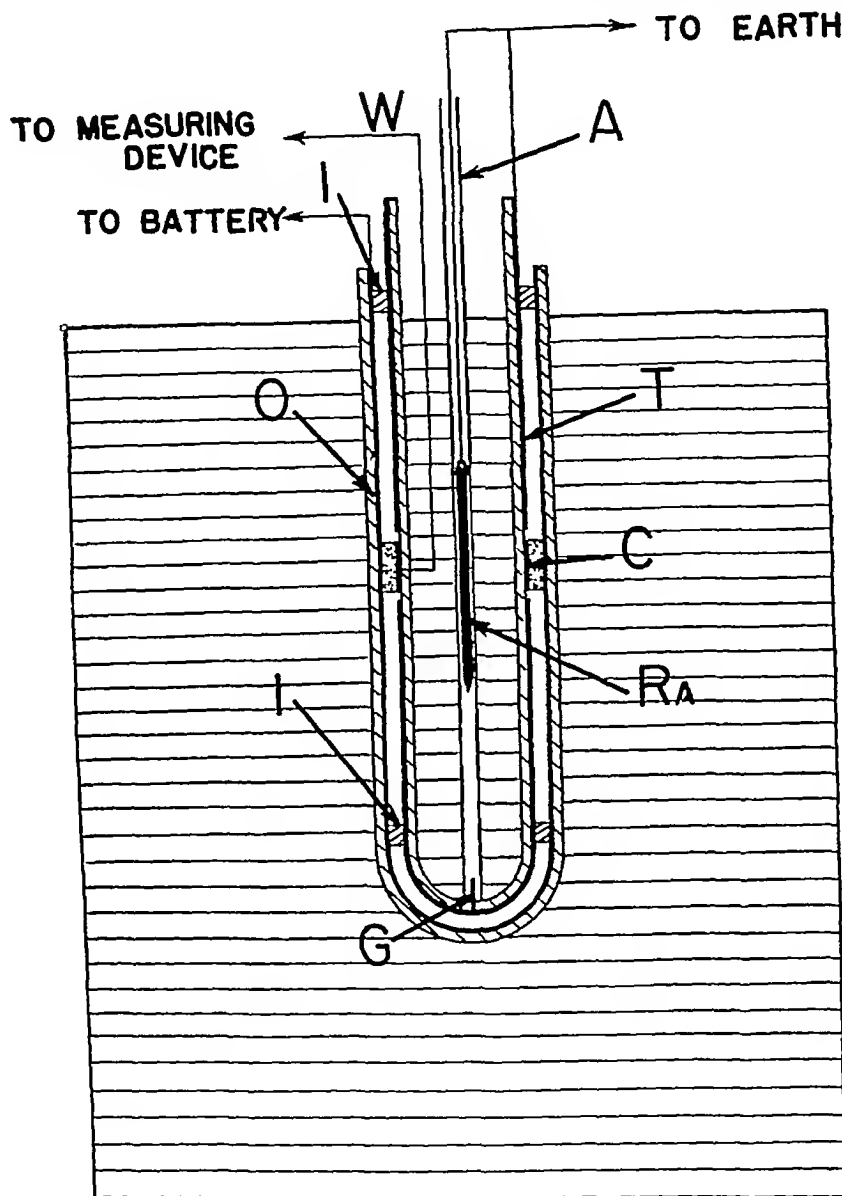


Fig 3 Extrapolation ionization chamber for the measurement of tissue doses in interstitial radium therapy

tion current is the average of the currents measured with positive and negative charges on the outer electrode

It is apparent that the determination of tissue doses by this method in the case of a radium needle or tube is a long and tedious process. So far we have not investigated

serious practical difficulties will be encountered. Since in practice it is not essential to know the dose at distances from the source shorter than several millimeters, the smallest chamber used need not be less than one centimeter in diameter. This reduces the mechanical difficulties of cham-

ber construction. By suitable modifications of the two types of extrapolation chamber described here it is possible to determine the tissue doses in terms of the air ionization which would be produced at any point in an irradiated tissue, for all methods of radiation treatment used to day.

In certain biological experiments very small test objects, such as *Drosophila* eggs or tumor fragments, are often irradiated in free air. Great care must be exercised in the measurement of tissue dose in such cases, particularly when gamma rays or supervoltage x-rays are used. One may determine the ionization at a certain point in atmospheric air by using thimble chambers of different wall thicknesses and extrapolating to zero wall thickness. In general this is a very difficult procedure. One must be able to eliminate not only the influence of the wall but also the influence of any material placed near the point in question in the process of making the measurements. How small the minimum wall thickness must be in order to permit extrapolation with reasonable accuracy, depends on circumstances—particularly on the range of the secondary electrons. In the case of gamma rays, measurements made with different chambers have not given us very consistent results, but we have not made a determined effort to overcome the difficulties since the problem is of no great interest. The important point to bear in mind in this connection is that the ionization produced in air at a certain point in a beam of radiation is not necessarily a measure of the tissue dose in a biological material placed at the same point, however small it may be. Each case presents a special problem which should be analyzed carefully.

The advent of neutrons and the rapid improvements in the methods of production, bring to us, with increasing urgency, the problem of measuring tissue doses in this case. So far as we can see to-day the extrapolation method is the only one which will give the desired information. In this case the agents directly responsible for the ionization are recoil particles the nature of

which depends on the material traversed by the neutrons. These high speed charged particles ionize any matter they traverse just as alpha particles and electrons do. Accordingly for convenience and as a first approximation we may take air as the medium in which the ionization is to be measured. However, it is of the utmost importance in the measurement of tissue doses of neutrons that the conditions under which the ionization in air is produced be exactly those which obtain in the biological material at the point where the biological effect is produced.⁹ For this reason the construction of suitable chambers of the extrapolation type is quite difficult. Two alternatives suggest themselves: (1) to make the chamber of "synthetic" materials having the exact chemical composition (insofar as elements are concerned) of the tissues in question, and (2) to make the chamber in such a way that the walls consist of the biological material itself, in the shape, volume, etc., in which it is at the time of the irradiation. Both are possible and we expect to construct some such chambers and conduct experiments with them in the near future. We may point out at this time an incidental advantage of the extrapolation type of chamber, in the measurement of ionization produced by recoil particles which liberate a large number of ions per unit path. It is difficult in this case to obtain saturation current, but with small air spaces such as employed in the extrapolation chamber, the problem is simplified. If necessary one can make use of the procedure followed by Taylor and Mohler (4) in determining the saturation current in liquids.

The problem of measuring tissue doses in the case of neutrons has been mentioned at this time primarily for the purpose of discussing the matter of units. As was expected it has been found that neutrons produce biological changes. What this will lead to no one can predict, but it is

⁹ A distinction should be made between the point at which the biological effect is produced and the point at which the biological effect manifests itself. The two are not necessarily the same.

certain that many biological experiments will be carried out in the near future. It is extremely important that the comparison of biological effects produced by neutrons and by the better known ionizing radiations (α -rays and gamma rays) be made under proper conditions. It may well be assumed for the present that ionization is at the bottom of all these effects. Hence the correlation of dose and effect may best be made (so far as we know to-day) by specifying the dose in terms of ionization. The tissue roentgen may be used as a unit of dose in the case of neutrons or any agent capable of producing radio-ionization directly or indirectly provided the ionization is measured under conditions which insure a proportionality factor which is independent of the quality or kind of the radiation between the ionization actually measured and that produced in the living material, at the point where the biological effect is produced. Since the tissue dose is the quantity of paramount importance in all biological applications of radiation, it is very desirable to have a universally accepted unit for it. Its definition might be as follows: The tissue roentgen is the quantity of any ionizing radiation capable of producing 1.62×10^{12} ion pairs per gram of air at a given point in a given medium under the conditions in which the radiation is to be utilized. It should be noted, however, that the definition is general enough

to cover any effect which may be brought about by any agent capable of producing radio-ionization (referred to by the general term "ionizing radiation"), irrespective of the nature of the effect (biological, chemical, or physical). Therefore, by leaving out the word "tissue" this could very well replace the present definition of the roentgen and thus remove the limitations which prevent the use of the unit in many cases. The suggested change would extend the use of the unit to other types of ionizing radiation and would clarify the situation without introducing complications in the ordinary α -ray range. It would make it unnecessary to have a separate unit of tissue dose. The desirability of such a change in the definition of the unit, the final wording, and the exact magnitude to be adopted, are matters which can be settled only by international agreement. It is extremely important that the subject be studied carefully and leisurely from all angles before final action is taken.

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CHOLECYSTOGRAPHY

FURTHER OBSERVATIONS ON THE USE OF PITRESSIN AND EVALUATION OF OTHER PROCEDURES

By E N COLLINS, M D , and JOSEPH C ROOT, M D , Cleveland Clinic, *Cleveland, Ohio*

FURTHER observations which have been made since our preliminary report (1) on the use of pitressin during cholecystographic examinations have resulted in the routine use of this pressor fraction of posterior pituitary extract whenever there are confusing shadows in the intestinal tract, provided no contraindications are present. Our experience with pitressin as well as with certain other procedures which increase the accuracy of cholecystography will be considered. Our routine method of combining cholecystography with the roentgen examination of adjacent organs will also be discussed.

Since the introduction of cholecystography by Graham and his co-workers in 1924 (2, 3), its importance in the diagnosis of dysfunction or disease of the gall bladder has become well established, but the technic of this procedure is still not standardized. Because of this lack of standardization, the clinician as well as the roentgenologist now insists upon knowing the details of the method used in order to judge its reliability.

From the roentgen standpoint, the diagnosis of disease of the gall bladder can be made from the cholecystographic evidence alone when it reveals the presence of gallstones, calcific deposits in the wall of the gall bladder, opaque bile in the gall bladder due to the presence of calcium carbonate bile (4, 5), or of neoplasms (6) in the gall bladder. However, unless the patient's history suggests the presence of these conditions, care should be taken in attributing the presenting symptoms to these causes unless abnormalities in adjacent organs are excluded. Normal cholecystographic findings do not necessarily indicate a normal gall bladder and non-visualization in the cholecystograms does not always indicate a pathologic gall bladder. Clinicians have been reluctant to place re-

liance on the cholecystographic findings when they did not adequately explain the cause of the patient's symptoms.

The clinical diagnosis of cholecystic disease is usually simple when the patient gives a history of one or more attacks of biliary colic, particularly if these have been associated with jaundice. In such instances, objective roentgen evidence for confirmation is obtained by cholecystography. In inflammatory diseases of the gall bladder, the physical examination usually offers no assistance unless the patient is examined during the acute or sub-acute phase of the process.

In the absence of a history of biliary colic, cholecystography is no less important but it must be combined with the roentgen examination of adjacent organs as well as correlated with the patient's symptoms in order to adequately explain the cause of the disability. In these instances the roentgen examination of adjacent organs often proves more valuable than cholecystography alone.

In this presentation we are chiefly interested in cases in which a characteristic history of biliary colic is absent, in which the roentgen examination of adjacent organs is combined with cholecystography, and in which the use of every important refinement in cholecystographic technic is needed in order to accurately determine the cause of the patient's presenting complaints. Soon after the introduction of cholecystography Nichols (7, 8) established the combined method of roentgen examination at the Cleveland Clinic, and these same procedures are used to-day, twelve years later. He has repeatedly emphasized the fact that, since the sympathetic nervous system through the superior and inferior mesenteric ganglia receives fibers not only from the gall bladder, but also from the stomach, duodenum, right kidney, ureter,

and colon, pain or distress in the right upper quadrant of the abdomen may be due to abnormality in any one or several of these organs. It is generally agreed that biliary disease is the most common *organic* cause of chronic gastro-intestinal symptoms in a middle-aged person. Routine autopsies, both in this country and abroad (9, 10), show that more than half the adults past 30 years of age had abnormal gall bladders and that approximately 20 per cent had gallstones, but the relatively low incidence of previous clinical evidence of biliary disease in these cases makes one question the advisability of prescribing surgery on the basis of cholecystographic evidence alone (11). It is well known that the best results from surgery of the gall bladder are obtained in those patients who have had definite biliary colic, and operations on the biliary tract are now seldom advised unless there is positive clinical as well as cholecystographic evidence.

It should be more generally recognized that the patient's gastro-intestinal symptoms may originate in the urinary tract. Urinary calculi as a cause of gastro-intestinal symptoms, particularly nausea and vomiting as well as pain, is well known. Patients have been operated upon for appendicitis or even intestinal obstruction when the trouble was in the urinary tract. Normal findings on routine urinalyses do not exclude abnormality in the urinary tract. In our cases of hypernephroma, the incidence of hematuria has not been greater than 50 per cent, and 34 per cent of our patients with hydronephrosis have had previous abdominal operations without relief of symptoms. Although hydronephrosis due to aberrant blood vessels apparently is a rare condition, it may simulate biliary disease, and almost invariably normal urinary findings are present. In 19 per cent of a group of patients with kidney tumors, there was no history indicative of disease of the urinary tract.

The interpretation of so-called gall-bladder dyspepsia or gaseous dyspepsia, as described in text-books, when it is not associ-

ated with definite attacks of biliary colic, is open to question. Although patients who give a history of biliary colic often have functional disturbances in the gastro-intestinal tract, Palmer (12) believes that, in the absence of this history, so-called gall-bladder dyspepsia is in reality independent of the gall bladder and that it is not unlike the dyspepsia which occurs in patients who are not afflicted with cholecystic or other forms of organic disease. In our experience, the most frequent cause for these indefinite symptoms is a functional disturbance in the colon, particularly in patients who have constipation or diarrhea, or one alternating with the other for a long time, and in whom catharsis, irritating enemas, or neurogenic factors may be important. When a complete examination excludes the possibility of organic disease, and this frequently includes examination of stools and proctoscopic examinations, we ascribe the condition to the "irritable colon syndrome," a term originated by the late B. W. Sippy.

In dealing with a patient who has indefinite gastro-intestinal symptoms, accurate diagnosis is usually made by a process of exclusion. Our aim has been to make the examinations which will be of the greatest practical benefit to the patient per unit of available time, and this generally means an investigation limited to two or three days. Our routine procedure has been to use the newer developments in cholecystography, the single or double oral method of administration of the dye, and at the same time complete the roentgen examinations of the stomach, small intestine, and colon. Prior to the administration of the cholecystographic dye, plain films of the gall-bladder area and urinary tract are made routinely. If abnormality in the latter is found, excretory urograms or retrograde pyelograms are completed before the administration of the barium meal. The time factor is the same as that required to complete the fractionated or multiple dose method of cholecystography alone.

In attempting to standardize cholecys-

tographic procedures, we believe the following features should be considered

1 After countless discussions relative to the merits of the intravenous *versus* the oral method of administering the dye, the oral method has had general adoption. This is the simpler method for both patient and roentgenologist, and from a practical standpoint very little if any accuracy in end-result is sacrificed. However, the intravenous method combined with determination of liver function, using "iso-iodeikon" (sodium phenoltetraiodophenolphthalein), as described by Graham (13), has been found important in dealing with a patient having obvious biliary disease, because of the added information relative to surgical risk.

2 The administration of multiple doses of the dye produces greater density in the visualized gall bladder than does the single dose, and it makes non-visualization of greater significance, without harming the patient.

3 The administration of large amounts of sugar and other carbohydrates preceding and during the examination facilitates the excretion of the dye by the liver, thereby adding greater significance to the cholecystographic findings.

4 One ounce or less of a mixture of egg yolk, lecithin, and glycerine, as recommended by Levyn (14), has been found to be as efficacious as the fat meal in emptying the gall bladder, and it has not interfered with the roentgen examination of the stomach or intestine on the same day that the cholecystograms are made.

5 The use of pitressin in the elimination of confusing shadows in that part of the intestinal tract which may lie over the area of the gall bladder has precluded the necessity for re-examinations in such instances. It has also made possible the use of the multiple dose oral method of cholecystography on the same days that the barium meal examinations of the stomach and small intestine or the barium enema examinations of the colon are made.

6 The importance of radiographic technique is well recognized but is too often

neglected. Kirklin (15), Barelay (16), and many others emphasize this feature. Adequate penetration of the gall-bladder area, using the minimum of kilovoltage as well as the shortest possible exposure time to eliminate motion, are the most important factors. Milliamperage higher than that commonly used as well as the use of a high speed Bucky diaphragm are desirable. The technique should be standardized so that accurate results may be repeated at will, and much depends on the interest of the radiographer and the care used in taking the films, as well as his skill.

Sandstrom (17, 18) introduced the "multiple" or "fractionated" method of cholecystography. He stated that "phenolphthalein preparations, once introduced into the system, circulate for a rather long time in an enterohepatic cycle. After being eliminated through the liver and its intermediary, the bile, they are reabsorbed through the intestines, and so on. By introducing orally during each phase of the cycle additional small doses of the salt one may obtain a more complete absorption." He administered orally 7 to 10 grams of sodium tetraiodophenolphthalein in two or three divided doses, allowing two or three days for the cholecystographic examination, and he found that greater absorption, resulting in greater density of the visualized gall bladder, was obtained without harm to the patient.

Sandstrom apparently allowed the patient to eat a mixed diet between the divided doses of the dye and so made no attempt to prevent emptying the gall bladder. Since carbohydrates had been shown to have no effect on the emptying time of the gall bladder in man (19), Whitaker and Ellsworth (20) modified the Sandström method by giving only carbohydrates between the two doses used in their "double oral" method. Whitaker (21) has since advocated that another carbohydrate meal be followed by a *third* dose of the dye if the roentgenograms at the end of 20 hours show no visualization of the gall bladder.

Stewart and Illick (22, 23) in their "intensified" oral cholecystography combine

the fractionated method of administration of the dye with the administration of large amounts of sugar to facilitate the excretion of the dye by the liver, allowing only carbohydrate foods until noon of the third day when a fat meal is given to empty the gall bladder

In our experience the use of the "fractionated" or "multiple" dose method is important when the cholecystographic findings are questionable, particularly when there is non-visualization by the single dose method. The single dose method, in our hands, has proved adequate in 90 per cent of the cases. We find that the greatest inaccuracy of cholecystography has been in those instances in which there is normal visualization of the gall bladder when chronic cholecystitis of clinical importance actually exists. We must remember that a gall bladder which is full of calcium-type stones often functions normally with cholecystographic dye, and we are convinced that the presence of calcium-type stones denotes cholecystitis. It would seem that the use of the smallest adequate amount of dye would reduce the inaccuracy mentioned.

In his "rapid" cholecystography, Antonucci (24) demonstrated the value of using glucose with the intravenous method. Ten minutes after the intravenous injection of 125 c c of a 40 per cent solution of glucose, the dye was injected. This, in turn, was followed by the subcutaneous injection of 24 units of insulin. Visualization of the gall bladder was usually obtained within half an hour following the injection of the dye, and the maximum intensity was reached in two hours. It was Antonucci's opinion that glucose played an important part in the utilization of the dye and that the absorption of the dye in the liver necessitated the presence of glucose either in the blood stream or as converted from glycogen in the tissues, if the former became exhausted. This coincides with our experience. We believe the more carbohydrates that are given during the cholecystographic procedures the better.

Cholecystograms which are taken after giving a fat meal may show the presence

of gallstones or neoplasms which are not apparent in former cholecystograms, but so far as function is concerned, we must remember that the gall bladder must empty in order to fill with the cholecystographic dye and that normal visualization of the gall bladder, as compared with plain films signifies a functioning gall bladder, so far as cholecystography is concerned.

CHOLECYSTOGRAPHY AND DETERMINATION OF LIVER FUNCTION

Blomstrom and Sandstrom (25) supplemented cholecystography with the bromsulphalein test in 68 cases as a means of determining the liver function in the event of non-visualization of the gall bladder after the administration of the dye. A high retention of bromsulphalein, over 40 per cent, excluded the possibility of visualization of the gall bladder because of liver damage. A low retention, however, below 25 per cent, indicated that obstruction was located outside the liver parenchyma.

Graham (13), in 1933, demonstrated the value of combining intravenous cholecystography with determination of liver function by the use of "iso-iodikon" (sodium phenoltetraiodophenolphthalein). He found that a knowledge of the amount of this dye which was excreted by the liver was of considerable value in estimating the risk of performing operations on the biliary tract. In addition, it was of assistance in the interpretation of the cholecystograms. By delaying operations until the proper medical treatment resulted in a reduction of high dye retentions to normal, the accuracy of the interpretation of the cholecystographic findings was increased, and the mortality rate for operation on the biliary tract could be reduced materially.

THE USE OF PITRESSIN DURING CHOLECYSTOGRAPHY

One of the handicaps to accurate interpretation of cholecystograms is the presence of confusing densities, such as gas shadows, in the intestinal tract. Repeated examinations may be necessary be-

fore an accurate diagnosis can be made. In our experience, the use of cathartics and enemas has proved not only inadequate,

We have used *pitressin* in 500 cases, this number being about 10 per cent of the total number of cholecystographic examinations



Fig 1 Gall bladder area obscured by barium in the colon



Fig 2 A normally functioning gall bladder visualized after administration of *pitressin*

but it has actually resulted in greater difficulties than were present before their administration in many instances. We have found the use of *pitressin*, the pressor fraction of posterior pituitary extract, effective in solving this problem, and its use is a simpler procedure, requires less time, is less troublesome to the patient, particularly if he is not in a hospital, and it has not been attended by unpleasant reactions. However, because of its stimulating effect on the musculature of the gastro-intestinal tract as well as its vasoconstrictor effects, it has not been used when there is danger of perforation or mechanical obstruction in the gastro-intestinal tract or in cases in which there is evidence of cardiovascular disease. We do not use *pitressin* in the presence of advanced hypertension, and since we have noted a drop in blood pressure in 60 per cent of our cases in which it has been used, it is not given to a patient whose systolic blood pressure is below 100 mm. of mercury.

made during that period of time. There is no need for its use routinely and if it is given in the presence of one or more of the above mentioned contra-indications the potential danger is obvious.

Effective results, *i.e.*, the elimination of confusing shadows in the intestinal tract, were obtained in 90 per cent of the cases. Figure 1 illustrates a case in which the second dose of dye was given the night following the routine examination of the stomach. It will be noted here that the entire gall-bladder area is obscured by barium in the colon, and no information about the function could be obtained by this cholecystogram. The patient was given 1 c.c. of *pitressin* and a second film was made 45 minutes later. The barium was evacuated from the colon, and we are now able to see in Figure 2 a normally functioning gall bladder.

In approximately 75 per cent of this group one or more stools occurred within 30 minutes.

Blood pressure readings were made before the administration of the pitressin and one hour after the injection in 300 cases, and in certain instances these readings were made every five minutes during the hour. There was a drop in the blood pressure in 60 per cent, and of this number there was a drop in both the systolic and diastolic pressure in 45 per cent. The average decrease for both the systolic and diastolic pressures was 12 mm. of mercury. An increase in blood pressure was experienced in only 20 per cent of the patients, and of this group there was an increase in both the systolic and diastolic pressure in 8 per cent. The average increase in the systolic pressure was 9 mm. and the diastolic pressure was 12 mm. of mercury.

The technic is merely the intramuscular (deltoid) injection of one ampule, 20 pressor units, when the first cholecystograms show confusing shadows in the intestinal tract. Additional films are then made one hour later. There has been no interference with the roentgen examination of the stomach, small intestine, or colon on the same day that pitressin is used.

This procedure is now our method of choice for the elimination of the confusing shadows mentioned and it is used routinely in such instances, provided no contraindications exist.

METHOD OF EXAMINATION

In patients who give a history highly suggestive of biliary colic, we obtain confirmatory evidence by making cholecystographic examination by the oral method, and this is combined with a roentgen examination of the stomach and duodenum to exclude the possibility of a penetrating ulcer in the posterior wall of the duodenum which may cause symptoms suggesting biliary disease in the absence of jaundice. Symptoms due to a neoplasm of the stomach have been ascribed to biliary disease.

A plain film of the urinary tract is always made at the time the preliminary plain films of the gall-bladder region are made. If the roentgen findings in the urinary tract are positive or suggestive of abnormality

the patient is referred to the Department of Genito-urinary Diseases for further examination before cholecystography is completed. Intravenous or retrograde pyelography may be indicated. There may be abnormality in the urinary tract as well as in the gall bladder, or the symptoms actually due to the former may be highly suggestive of the latter.

In rare instances, a calcification is visualized which may be either in the gall bladder or in the pelvis of the right kidney. As pointed out by Nichols, a consideration of the physics of the technic makes the differentiation simple when the characteristics and position of the shadows are compared in both the gall-bladder film, made in the postero-anterior position, and the urinary tract film, made in the anteroposterior position. The closer the object is to the film the smaller and more distinct it will be.

Various forms and amounts of the dye and various modifications have been used with the dye, but, in our hands, the plain dye (sodium tetraiodophenolphthalein) taken in grape juice or other fruit juices has caused the least discomfort and has given the most satisfactory results from the standpoint of absorption. The one ounce bottle given to the patient contains 5 grams of the dye, one and one-half drams of paregoric, and distilled water, prepared on the day of administration. Immediately after the six o'clock high-carbohydrate-fat-free meal the patient shakes the bottle, empties its contents into a glass containing the fruit juice, stirs thoroughly, and drinks it all quickly. The following morning black coffee or clear tea with as much sugar as desired are allowed. Emphasis is placed on the ingestion of as much sugar as possible at all times during cholecystography.

The first cholecystograms are made 14 hours after the ingestion of the dye. If these films are satisfactory, as is the usual case, the roentgen examination of the stomach and duodenum is done without further delay. If the 14-hour cholecystograms show insufficient or non-visualization of the gall bladder, the latter ex-

amination is delayed until 16-hour cholecystograms are made. If questionable shadows are present, or if the gall bladder

have found that in this group the second dose is well tolerated and it is a rare occurrence for the dye not to be retained



Fig 3 Questionable opaque calculus in gall bladder area



Fig 4 The gall bladder contracted after administration of lecithin mixture. Questionable shadow now outside of the gall bladder

is obscured by shadows in the intestinal tract, use is made of the lecithin mixture or pitressin or the two procedures may be combined. If the findings are still questionable, particularly if there is insufficient or non-visualization of the gall bladder, a second dose of the dye is given the second night, even though the roentgen examination of the stomach and small intestine is made on the same day the cholecystograms are made. The 6-hour gastric retention film often shows excellent visualization of the gall bladder. We believe that a second dose of dye should always be given on the second night of the examination if the gall bladder is not visualized initially or if the density is so slight that the presence of non-opaque calculi cannot be determined with a high degree of accuracy. A second dose should also be used routinely if the patient happens to be of the small group that may vomit the dye before there is sufficient time for its absorption, resulting in non-visualization of the gall bladder. We

Although the lecithin mixture is frequently used, pitressin or a second dose of the dye has not been indicated in more than 10 per cent of our cases. We find that the gall bladder has diminished at least 50 per cent in size one-half hour after the oral administration of five drams of the lecithin mixture. This amount has not been found to interfere with the roentgen examination of the stomach one-half to one hour after its administration. The use of this mixture has supplanted the use of the fat meal in our hands and, although not used routinely, it has been very helpful in determining the significance of questionable shadows in the area of the gall bladder. Figure 3 shows a small opaque calculus in the gall-bladder area, which, at this time, cannot be excluded as an opaque calculus. The patient was given four drams of the lecithin mixture, and the second film was made one-half hour later. Figure 4 shows the gall bladder in a contracted state with the suspicious shadow outside the gall-bladder

area The fat meal may be given during the course of the combined gastro-intestinal examination, four to six hours after the multiple dose method of administering the dye is not necessary as a routine procedure in cholecystography As stated, the examina-

TABLE I

Cholecystographic Findings	Number of Cases	Pathologic Findings				
		Chronic Cholecystitis			Ca. carb , bile, and stones	Grossly normal
		With stones	Without stones	Stone, cystic duct		
Normally functioning gall bladder without stones (negative)	5		4	1		
Normally functioning gall bladder with evidence of adhesions	1		1			
Gallstones in a normally functioning gall bladder	37	35	2			
Gallstones in a poorly visualized gall bladder	29	27	2			
Poorly visualized gall bladder without evidence of stones	6		6			
Gallstones in non visualized gall bladder	31	31				
Non visualized gall bladder without evidence of opaque stones	40	33	6			1
Non functioning gall bladder with calcium carbonate bile and stones	1			1	1	

stomach examination, but the possibility that the gall-bladder area will be obscured by barium in the intestinal tract is present.

In the large group of patients who give an indefinite history of digestive disturbances, motility studies of the small intestine as well as barium enema examinations of the colon are added to the procedures mentioned. *This constitutes our routine gastro-intestinal series examination.* Those patients who are to have a colon examination on the following morning take from one to two ounces of castor oil after the six-hour gastric retention film is made.

In instances in which a second dose of the dye is given on the second night, even though barium meal examinations of the stomach and small intestines have been done, the use of pitressin is often needed in order to satisfactorily visualize the gall bladder the following morning. No cathartics are given when further cholecystographic procedures are to follow. Methods used in the roentgen examination of the colon have been published elsewhere (26).

We believe that the fractionated or mul-

tion of organs adjacent to the gall bladder is often more important in establishing the cause of the patient's presenting symptoms than cholecystography alone. Time and expense to the patient are important factors.

RESULTS

Establishing the accuracy of cholecystography is, of course, difficult, because relatively few of the patients in whom these examinations are made have abdominal operations. However, our findings in abdominal operations during the past five years have coincided with the cholecystographic findings in either a positive or negative way in 95 per cent of the cases. In a series of 150 patients having cholecystectomies, the cholecystographic findings were accurate in 93 per cent. The cholecystographic examinations in this series of cases, in the majority of instances, were made before the employment of the lecithin mixture, the occasional second dose of dye, and before the use of pitressin. In Table I is a summary of the cholecystographic

and pathologic findings in parallel groupings

In a consideration of the errors, there were five cases on the negative side in which normal cholecystographic findings had been obtained and little gross evidence of abnormality of the gall bladder was found at operation, but the microscopic diagnosis was chronic cholecystitis. In four of these, there were no stones, in the fifth case there was a stone in the cystic duct but none in the gall bladder. The clinical significance of a microscopic diagnosis of chronic cholecystitis in the absence of definite gross pathologic changes is disputed by many authorities.

On the positive side, a diagnosis of gallstones was made in four instances, but operation did not confirm this, however, pathologic gall bladders were found. Two of these four patients had poorly visualized gall bladders by cholecystogram which apparently indicated diminished function. Another positive diagnostic error was made in a case of non-visualization in which the gall bladder was found to be grossly normal at the time of operation, and the appendix was definitely pathologic. This type of error is bound to occur since conditions extrinsic to the gall bladder are known to produce non-visualization of the gall bladder by cholecystography.

EVALUATION OF CHOLECYSTOGRAPHIC FINDINGS

Statistics relative to the accuracy of cholecystography are generally based on operative findings. Because of this, the cholecystographic evidence alone is open to question. In most instances there is positive clinical as well as positive cholecystographic evidence of biliary disease before operation. However, Kirklin and Blake (27) have summarized the cholecystographic evidence in patients who have not had abdominal operation but who did have a final clinical diagnosis of cholecystic disease. They found that the cholecystographic data coincided with the clinical diagnosis in approximately 90 per cent,

which approaches the accuracy of cholecystography in cases proved by operation.

We believe the following are important features to be considered in a practical evaluation of cholecystography.

A gall bladder normally visualized by cholecystography may be pathologic, even though in most instances it denotes a normal gall bladder. Convincing clinical evidence is necessary in order to justify surgery on the grounds of biliary disease if the cholecystographic findings are normal.

On the other hand, gall bladders which are full of calcium-type stones commonly function normally with the cholecystographic dye. In the absence of gallstones, the routine use of multiple doses of dye should logically increase the error in diagnosis so far as normally functioning gall bladders by cholecystography alone are concerned. There must be many patients who have symptoms due to chronic cholecystitis without stones who have normal cholecystographic findings. Giving the smallest possible adequate dose of cholecystographic dye should decrease the error in the roentgen interpretation of these cases. The patient should not be told that his gall bladder is normal on the basis of cholecystographic findings alone.

Non-visualization of the gall bladder without evidence of opaque calculi usually indicates a non-functioning gall bladder containing calculi of the cholesterol type, often blocking the cystic duct. But consideration must be given to the possibility of other causes of non-visualization, such as diseases of the liver or diseases in adjacent organs which may cause reflex disturbance in the dye-concentrating ability of the gall bladder or dysfunction in the sphincter of Oddi. An active duodenal ulcer may cause non-visualization. In other words, non-visualization does not necessarily indicate a pathologic gall bladder, and such a diagnosis should not be made unless there is a suggestive history of biliary disease and roentgen examination of adjacent organs reveals no evidence of abnormality. The multiple dose method of administering the dye, combined with

a large intake of sugar, is definitely indicated in the event of non-visualization. Added doses at each phase of the entero-hepatic cycle usually are more effective than a re-check single dose examination at a later date unless there is abnormality outside the biliary tract causing reflex disturbances which are relieved in the meantime.

CONCLUSIONS

1 In a group of 150 patients who have had cholecystectomy, the operative findings coincided with the cholecystographic findings in either a positive or negative way in 93 per cent of the cases.

2 The use of a single dose of dye has been found adequate in 90 per cent of our cholecystographic examinations. In the event of non-visualization or questionable findings with the single dose method, a second dose of dye is given the second night.

3 The use of pitressin has been found effective in the elimination of confusing shadows in the intestinal tract. Its routine use has not been necessary. During 5,000 cholecystographic examinations it was used in approximately 10 per cent of the cases. Contra-indications to its use have been established.

4 The routine use of the combined method, *i.e.*, combining the roentgen examination of adjacent organs with cholecystography, has proved valuable during 12 years of experience. The extent of the examinations of adjacent organs has been determined by the presence or absence of a history of definite biliary colic in each case. Abnormal cholecystographic findings do not necessarily explain the cause of the patient's abdominal symptoms.

5 The use of the lecithin mixture to supplant the fat meal and the use of pitressin when indicated has made possible the completion of the combined method of roentgen examinations, using either the single or double oral method of cholecystography, in the time required to do the multiple dose method of cholecystography alone.

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On the positive side, a diagnosis of gallstones was made in four instances, but operation did not confirm this, however, pathologic gall bladders were found. Two of these four patients had poorly visualized gall bladders by cholecystogram which apparently indicated diminished function. Another positive diagnostic error was made in a case of non-visualization in which the gall bladder was found to be grossly normal at the time of operation, and the appendix was definitely pathologic. This type of error is bound to occur since conditions extrinsic to the gall bladder are known to produce non-visualization of the gall bladder by cholecystography.

EVALUATION OF CHOLECYSTOGRAPHIC FINDINGS

Statistics relative to the accuracy of cholecystography are generally based on operative findings. Because of this, the cholecystographic evidence alone is open to question. In most instances there is positive clinical as well as positive cholecystographic evidence of biliary disease before operation. However, Kirklin and Blake (27) have summarized the cholecystographic evidence in patients who have not had abdominal operation but who did have a final clinical diagnosis of cholelithiasis. They found that the cholecystographic data concided with the clinical diagnosis in approximately 90 per cent,

which approaches the accuracy of cholecystography in cases proved by operation.

We believe the following are important features to be considered in a practical evaluation of cholecystography.

A gall bladder normally visualized by cholecystography may be pathologic, even though in most instances it denotes a normal gall bladder. Convincing clinical evidence is necessary in order to justify surgery on the grounds of biliary disease if the cholecystographic findings are normal.

On the other hand, gall bladders which are full of calcium-type stones commonly function normally with the cholecystographic dye. In the absence of gallstones, the routine use of multiple doses of dye should logically increase the error in diagnosis so far as normally functioning gall bladders by cholecystography alone are concerned. There must be many patients who have symptoms due to chronic cholecystitis without stones who have normal cholecystographic findings. Giving the smallest possible adequate dose of cholecystographic dye should decrease the error in the roentgen interpretation of these cases. The patient should not be told that his gall bladder is normal on the basis of cholecystographic findings alone.

Non-visualization of the gall bladder without evidence of opaque calculi usually indicates a non-functioning gall bladder containing calculi of the cholesterol type, often blocking the cystic duct. But consideration must be given to the possibility of other causes of non-visualization, such as diseases of the liver or diseases in adjacent organs which may cause reflex disturbance in the dye-concentrating ability of the gall bladder or dysfunction in the sphincter of Oddi. An active duodenal ulcer may cause non-visualization. In other words, non-visualization does not necessarily indicate a pathologic gall bladder, and such a diagnosis should not be made unless there is a suggestive history of biliary disease and roentgen examination of adjacent organs reveals no evidence of abnormality. The multiple dose method of administering the dye, combined with

FRACTURE OF THE ATLAS OR DEVELOPMENTAL ABNORMALITY?

By H F PLAUT, M D , Cincinnati, Ohio

THE following is the report of a patient seen after an automobile accident, July 17, 1936. A colored girl, student, 18 years of age, was admitted to the St Philip's Hospital, Medical College of Virginia, Richmond, Va (Neurosurgical Department, service of Dr C C Coleman),

the axis, mashing that part of the atlas-ring in between. In the further course no neurological changes or deafness were observed.

Three days later another roentgen examination was made. In the lateral view there was a large bilateral gap in the pos-

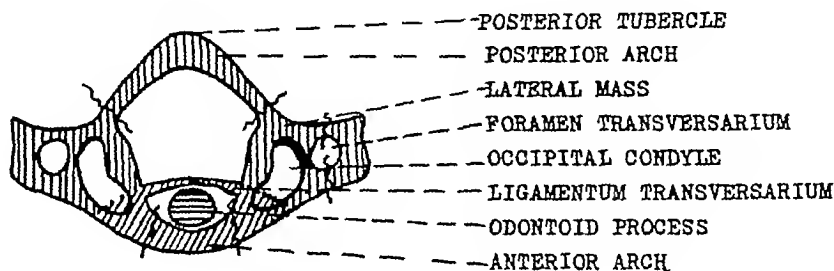


Fig 1 Diagram of the human atlas, showing its morphological parts and fracture sites. The greater part is formed by the basidorsals, the basiventrals form a ring surrounding the odontoid process of the axis and composed of the bony anterior arch, including the anterior ends of the condyles, and the fibrous ligamentum transversarium. The odontoid process is the separated interventral of the atlas. (Modified after Gadow.)

about fifteen minutes after she had jumped from the rumble seat of a moving automobile. She had projectile vomiting about ten minutes after admission. She was unconscious, showed a soft swelling of lemon-size over the left parietal region, and there was oozing of blood from the left ear without demonstrable abrasion in the auditory canal. The pupils reacted to light and were equal in size. No rigidity of the neck was found.

Immediate x-ray examination revealed a definite fracture line through the parietal bone on either side (see Fig 3). The fracture line followed the lambdoid suture rather closely on the right side and was situated more anteriorly on the left with another fracture line extending through the region of the sella on the left side. This fracture line apparently did not separate the sphenoid but the bone overlapping the sphenoid. The head was seen to be lower than usual, as if the lower part of the occiput was pressed against the arch of

terior arch about 8 mm wide (see Fig 4). The axis was in normal position. On July 27 the patient was discharged, on her request, with a Thomas collar.

DISCUSSION

A case reported by Lawrence and Anderson (13) has many similar features. Their female patient was sitting in an automobile when a street car bumped into it. Her head jerked backward with some violence. On account of the x-ray findings, a diagnosis of fracture of the posterior arch of the atlas was made by the attending surgeon. This was also the first impression of the authors. When re-examined for medico-legal purposes ten days after the accident, the patient still complained about stiffness in the neck. A space about one-half inch wide, separating the undisplaced portion of the posterior arch from the anterior portions of the vertebræ, was noted. No fragments were seen in the gap. The

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tively, after the accident to the patient under discussion and Lawrence and Anderson's patient

in the fifth to ninth year. A separate ossification center may be present in the region of the posterior tubercle and possibly



Fig 3 Roentgenogram of skull, taken immediately after accident, with upper cervical vertebrae in rotated position

One may assume that the prevailing cause of fractures of the atlas is a violent pressure of the skull against the cervical spine when fixed in a rather straight position. The character of the trauma in our patient could quite well produce a fracture of the atlas. A displacement of the fragments does not necessarily take place. A review of the literature about fractures of the atlas, accompanied by excellent roentgenograms, fails to show similar changes to those described by Lawrence and in this article. There were reports of fractures into numerous pieces, but no gaps of this extent. On the other hand, there are no such formations mentioned among the variations and developmental abnormalities of the atlas.

The atlas ossifies from three main centers. Two, one for each lateral mass extending into the posterior arch, are present at birth and unite posteriorly in the third to fifth year of age. The third center appears around the first year of life in the anterior arch and unites with the two lateral centers

a groove, occasionally noted in this region, is due to missing of this center.

Gap formations illustrate the tendency of the human atlas to undergo further regression. The overwhelming majority of the gaps in the posterior arch lies near the midline, very rarely are they seen near the lateral masses. The width ranges from a fissure to about ten millimeters, and even nearly complete absence of the posterior arch is known. In the anterior arch gap formations are less frequent. During life, interruptions of the atlas due to persisting cartilage seams or gap formations were demonstrated roentgenologically by Renander (11), Arkusky, Englander (6), and Lorey (12). Until 1932 Geipel (7) found, among 1,136 spines, 35 cases with fissures and gaps in the atlas ring. He had an opportunity to examine part of the specimens histologically and observed firm tracts of connective tissue leading from one end of the gap to the other, originating from the periosteum and inserting at the bone. Another connection of the two

diagnosis then was altered to one of rare developmental abnormality. Objective neurologic changes were not mentioned. It would be desirable to know if the head probably hit the automobile from behind. It would be desirable to know if the head struck any part inside the car and if there

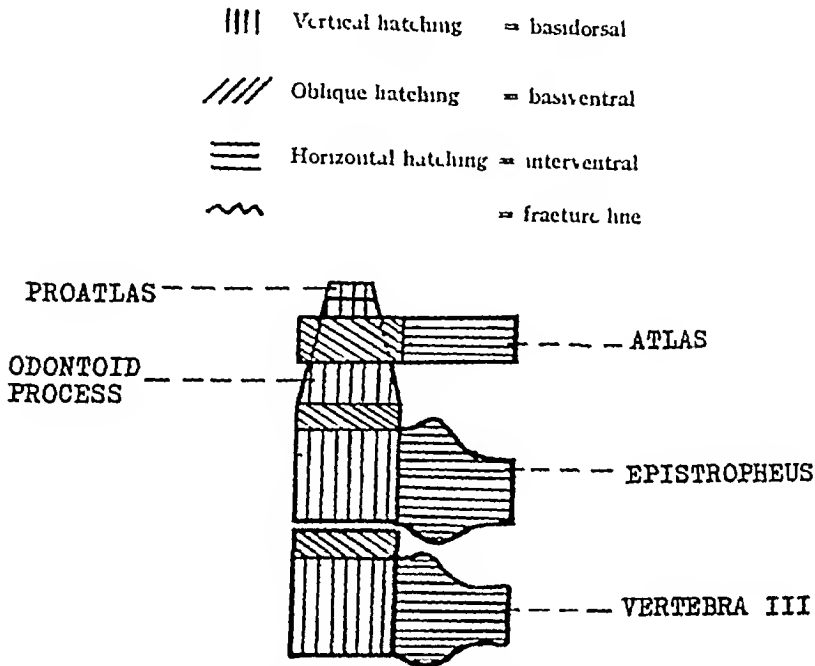


Fig. 2. Scheme of first three vertebrae. The first vertebra, or atlas, is composed of basidorsal and basiventral elements. The odontoid process of the epistropheus which is seen passing through the first basiventral is the intervertebral of the atlas. The tip of the odontoid process is formed by the intervertebral of the proatlas. The second vertebra, or epistropheus, consists of the fused and ossified basidorsal intervertebral, and basiventral, to the last of which the odontoid process is also fused. The third vertebra is a typical vertebra formed of the co-ossified basidorsal and intervertebral, with the basiventral forming the intervertebral fibro-cartilage between it and the epistropheus. (After Gadow.)

It is interesting to study the facts concerning these two cases in order to discuss the differential diagnosis of injuries and anomalies of the atlas. Strassmann describes a transverse rupture of the trachea, and Romanese (14) a fracture of the third cervical vertebra, both fatal lesions without any signs of direct force to the neck, alone due to a backward jerk of the head when the individual was hit from behind by an automobile. The relaxation of the musculature at the moment of the unsuspected violent trauma is made responsible for these surprisingly severe injuries. Judging from the description of the accident in Lawrence's case, the street car

were any skin lesions, swellings, or other signs of direct trauma.

At the first examination of our patient we had the impression that her upper neck was shorter than usual, although its rotated position was taken into consideration. The skull appeared to be pressed into the gap of the posterior arch of the atlas against the axis. Because of the overlapping of the mastoid process it was rather difficult to make a definite decision as to the presence of fragments but there seemed to be more calcified tissue than was due to the mastoid. The fact is striking that no fragments of bone were visible in the wide gap of three days and ten days, respec-

Without satisfactory lateral roentgenograms taken before or immediately after the accident to demonstrate fragments, or at least such views taken several months thereafter for signs of reparation, it is hardly possible to make a reliable decision as to the nature of the findings. It is noteworthy that the changes were found only in two cases with definite and severe indirect trauma to the neck. For this last reason I would be more inclined to regard them as a bilateral fracture of the posterior arch of the atlas with hitherto unknown comminution. However, the facts are not absolutely conclusive without further study of the subject.

SUMMARY

A case out of a series of atlas fractures shows unusual width of bilateral gaps in the posterior arch, which raises the question of developmental abnormality. It is compared with the only similar case found in the literature with interesting medicolegal consequences, likewise seen after a severe indirect injury of the cervical spine in an automobile rider. The mechanism of fractures of the atlas is discussed, as well as embryonic development, the variations and abnormalities of this vertebra. The exceptional trend for decalcification and the lack of callus formation in this region deserve special consideration. As

no re-examination could be performed, definite decision as to the nature of the lesion is postponed.

19 West Seventh St

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ends was seen in one of those rare cases of entirely missing posterior arch a flaccid band formed by the posterior membrane



Fig. 4 View of cervical spine taken three days after accident in lateral direction

(a tense band would narrow the canal too much to allow sufficient space for the cord) However, no bone formation could be demonstrated in any of these fibrous strings

Decalcification—Another point has to be borne in mind. Lack of callus and pseudarthroses after fractures of the three upper cervical vertebrae were seen by quite a few authors. One of our patients, whom we had the opportunity of re-examining roentgenologically eight months after his bilateral fracture of the atlas, also showed this phenomenon. Spontaneous dislocations of the atlas in children have been not infrequently reported in recent years after inflammations of the upper respiratory tract and neighboring tissues (15). These luxations occurred as early as from one to two weeks after the upper respiratory in-

fection and were found to be due to loosening of the attachments of the transverse ligament. From these cases we likewise must assume that an exceptional opportunity exists for decalcification.

It seems to be very difficult to do justice to the remaining possibility of a tear or break in a mostly cartilaginous posterior arch, because the roentgenological signs are few. A dislocation of the separated posterior piece of bone, however, would speak very much in favor of a traumatic lesion. While in other regions of the body clinical findings may help, they certainly disappoint in a case like ours. As a rule a fracture of the skull overshadows the coinciding fracture of the atlas in the clinical picture and decides the final result.

Mortality—For fractures of the atlas, Jefferson (4), states that of 32 cases reported from 1900-1927 only six patients have died. The mortality in recent years has been very low. Among the 29 cases which were added by a review of the literature and our own cases, there were only three casualties, so that one's impression at present is that atlas fracture, though fraught with the possibility of danger, is by no means always fatal.

As to differential diagnosis it would have been of immense value for us to be able to follow the subsequent course, not to speak of a roentgenogram made before the accident. However, we did not succeed in our efforts to induce the patient to appear for roentgenographic control.

CONCLUSIONS

The following table shows the reasons for one or the other diagnosis

Fracture	Abnormality
History	
No such malformations reported	No such fractures reported
Ossification center in posterior tubercle is constant and not reported in malformations due to arrest of development	No clinical signs no rigidity of neck
Exceptional opportunity for decalcification in this region	No fragments noted 3 days after injury
Site of most frequent bilateral fracture	No dislocation of posterior piece of bone

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ROENTGEN KYMOGRAPHY

Interest in roentgen kymography has been gradually increasing since Dr. Pleikart Stumpf, of Munich, devised the multiple slit grid in 1928. At this stage in the development of kymography it seems appropriate to discuss the principles and purposes of the procedure and to emphasize its defects and shortcomings. Basically, kymography is a method for graphically recording the functional or physiological movements of an organ or structure on an x-ray film. Kymograms are records of movement. The procedure is limited by the following factors:

(1) Only organs or structures that are bordered by tissues of a contrasting density can be studied kymographically.

(2) Many organs and structures possess complicated movements in several different planes, such as the heart, which not only enlarges and contracts laterally and medially, but simultaneously changes its size in a vertical plane and also undergoes a rotary motion about a central axis. Unfortunately, a kymogram is but the record of one component of these complex motions.

(3) In recording the movements of a rounded or an obliquely placed object, the only motion accurately registered is that which occurs in a direction parallel to the slits and with the border of the object lying at right-angles to the slits.

(4) Only pathologic lesions that alter the way in which a structure moves, functions, fills, or empties, produce kymograms with characteristically different waves or records.

Keeping these limitations in mind, roentgen kymography is a reliable method for studying the motions of suitable structures and can be successfully used wherever it is desirable to record in detail the extent, direction, speed, duration, and time occurrence of movement. Kymography is not designed to replace roentgenoscopy, but to supplement it. The procedure may be considered as an additional and

specialized tool to the armamentarium of the radiologist for the study of the physiologic motion exhibited by organs and structures. It is especially well adapted for research and investigative work in cases in which a permanent and objective record is required.

Clinically, the heart has been most extensively studied. The information obtained from kymograms has been useful in confirming established knowledge rather than introducing new ideas. Kymography has, however, served as a great impetus to the clinical study of cardiac physiology. It has added a physiologic aspect to the radiologic interpretations of heart disease. If this additional bit of knowledge aids in the diagnosis, then kymography is of value. In the diagnosis of the average cardiac patient in whom the history, physical examination, and laboratory reports are available, the roentgen kymogram will not provide additional information. It may be regarded as helpful, but not necessary, and somewhat comparable to the degree of importance given to the electrocardiogram. In selected cases the kymogram may be the main factor in establishing or confirming the diagnosis.

In the interpretation of kymograms the size and shape of the cardiac silhouette should be analyzed first. Then the movement waves are studied with the prospect of gaining additional information.

The respiratory movements of the ribs, diaphragm, lungs, and mediastinum can be easily recorded by kymography. The study of thoracic movements may become one of its chief uses. The stomach, duodenum, kidney pelvis, and ureters have been similarly studied, but kymograms of these organs are of less practical value because of their slow movements and the consequent long exposure time.

Mechanically the apparatus is simple and commercially perfected. Home-made equipment is satisfactory if the slits are accurately

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By translating every speech into English, French, and German, we believe that nearly everyone will receive the benefit of understanding the more than 250 speakers who will read scientific papers during the five-day meeting here September 13 to 17."

It will be the first International Congress ever held in the United States, Dr Christie added, and will mark the forty-second year since Dr William Conrad Roentgen discovered x-rays, and the thirty-ninth year since the Curies discovered radium. The vast progress made in development of the medical and other uses of these two boons to mankind will be portrayed during the Congress, not only through the scientific papers and discussions, but in actual graphic exhibits.

The Congress will be held at the Palmer House, Chicago, where more than 12,000 square feet of floor space will be devoted to an extensive scientific exhibit to be arranged by scores of hospitals and research laboratories throughout the world. Over 20,000 square feet will be devoted to commercial exhibits, showing the latest equipment manufactured by leaders in the field, ranging from x-ray negatives up to models of million-volt therapy apparatus.

A "short-term" medical school will be conducted during the Congress, said Dr Christie. Eminent leaders in the field of radiology will conduct short courses during the Congress for the benefit of delegates who will attend the Congress from all parts of the world. All of the United States radiological societies, including the Radiological Society of North America, American Roentgen Ray Society, American College of Radiology, and American Radium Society, will hold their joint annual meetings during the Congress and will elect officers here. At least 500 foreign delegates are expected from 30 different countries, and over 2,000 United States physicians will attend.

Included among the outstanding scientists of the world who will be present at the meeting are Dr Gösta Forssell, of Stockholm, Sweden, Dr Antoine Béclère, of Paris, Dr Tamotsu Watanabe, of Osaka, Japan, Dr H Tellez-Plasencia, of Santander, Spain, Dr Russell Reynolds, of London, Dr William D Coolidge, of Schenectady, N Y, Dr C Thurstan Holland, of Liverpool, England, Dr George E Pfahler, of Philadelphia, Pa, Dr Francis Carter Wood, of New York City, Dr James Ewing, of New York City, and Dr William J Mayo, of Rochester, Minnesota.

COMMUNICATIONS

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December, 1936

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E L Harrington, University of Saskatchewan, Saskatoon, Canada.

G M Shrum, University of British Columbia, Vancouver, Canada.

J Demers, University of Montreal, Montreal, Canada

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The question was raised as to how sharp a line should be drawn between industrially employed physicists who are ineligible for certification and those physicists employed in strictly clinical, standardization, or consultative capacity. "Manufacturer," in the sense used by the Committee, means any person, group of persons, or company which is directly interested in the manufacture or sale of any article or equipment to the radiologist. The Committee desires, however, to place on record that it recognizes the high quality of the physicists employed by the various manufacturers and does not mean to imply in any sense

spaced, of uniform width, and not wider than 0.5 mm. The film must move smoothly and at a uniform rate of speed. Small films (10 X 12) may be used for the heart, to lower the cost.

As with all new methods, familiarity with a procedure is gained through experience and practice. Confidence is established by confirming the diagnoses at the operating table and postmortem examination, but only time properly evaluates a procedure.

WENDELL G. SCOTT, M.D.

ANNOUNCEMENT

FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

PALMER HOUSE, CHICAGO

September 13-17, 1937

Membership in the Fifth International Congress of Radiology closed on Aug. 14, 1937. Early closing dates for membership in conventions of this character constitute one of the disappointing features which can not be avoided. Those who have forwarded their applications for membership since that date will understand that the officers and organizers of the Congress regret that it became necessary, inasmuch as the Portrait Catalogue and other publications of the Congress must be completed and ready for distribution when registration is opened at 1 P.M. Sunday, Sept. 12, 1937.

Attendance at the Congress is not limited to members of the Congress. By the payment of a small registration fee, one may be registered as a guest of the Congress and enjoy the full privileges of the scientific program and scientific exhibits throughout the period of the Congress.

Educational courses, which are free to members of the Congress, are open to registered guests of the Congress upon the payment of an additional registration fee. The very nature of the educational courses naturally limits the numbers that may be accommodated, and registration for the courses will close accordingly. For further information concerning these courses, please refer to the July issue of this Journal, page 119, or write your inquiry to the Secretariat, 2561 North Clark Street, Chicago.

The Grand Banquet, which occurs on Friday evening as the closing feature of the Congress, is free to all of the members and associate members.

Registered guests of the Congress will be required to purchase tickets at the registration desk if they wish to attend the Grand Banquet. They may also register associate members of the Congress by the payment of the regular associate membership fee.

It is exceedingly important that the guests as well as the associate members be registered as far ahead of the opening of the Congress as possible in order that the committees providing entertainment features may know the approximate number for which arrangements are to be made.

Contributions to the scientific program will be presented in the three official languages of the Congress. In addition to the language used by the essayist, the content of his address will be projected on a screen in the other two official languages of the Congress and they will be synchronized as far as possible with the address as it is delivered. It is obvious that this feature will add greatly to the success of this Congress, since a very great majority of the audience in the forenoon general sessions, and in the afternoon sectional meetings, will be English-speaking and -understanding, while the Contributors' presentations will be more equally divided between English, German, and French.

It would appear that almost every radiologist will endeavor to attend this Congress. It is the first opportunity American radiologists have had to attend a Congress within our own country with contributors representing all of the leading countries of the world. Furthermore, it is the first time that a program for an international congress of radiology has been so arranged that all of the guests will be able to understand any contribution they choose to hear.

With approximately 300 contributions on the program, one may choose papers from any phase of radiology and learn of the most recent advances in that particular field.

"Most of the European scientists are at least bilingual," explained Dr. Christie, President of the Congress, "but many United States physicians who will attend are not sufficiently conversant with more than English to comprehend many of the papers which will be read."

By translating every speech into English, French, and German, we believe that nearly everyone will receive the benefit of understanding the more than 250 speakers who will read scientific papers during the five-day meeting here September 13 to 17 "

It will be the first International Congress ever held in the United States, Dr Christie added, and will mark the forty-second year since Dr William Conrad Roentgen discovered x-rays, and the thirty-ninth year since the Curies discovered radium. The vast progress made in development of the medical and other uses of these two boons to mankind will be portrayed during the Congress, not only through the scientific papers and discussions, but in actual graphic exhibits.

The Congress will be held at the Palmer House, Chicago, where more than 12,000 square feet of floor space will be devoted to an extensive scientific exhibit to be arranged by scores of hospitals and research laboratories throughout the world. Over 20,000 square feet will be devoted to commercial exhibits, showing the latest equipment manufactured by leaders in the field, ranging from x-ray negatives up to models of million-volt therapy apparatus.

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that they do not possess the same qualifications as a registered physicist. One of the principal purposes of the Registry is to establish a list of physicists available for consultative purposes without being hampered by any possible industrial affiliations.

It was agreed that any registered physicist who, subsequent to his certification, becomes affiliated with a manufacturer, shall automatically and without notice be dropped from the certified list. If such a physicist closes such an affiliation, a new application for certification may be submitted to the Board.

II Certified X-ray Standardization Laboratories—In the interests of radiology it is agreed by the Committee that all dosage meters in clinical use shall be calibrated and certified by a recognized x-ray standardization laboratory, meeting the following requirements:

1. Equipment must be in charge of a full-time physicist, whose special field is that of x-rays and whose basic training has been in physics.

2. The standardizing laboratory must be equipped with the necessary working standards for effecting a complete calibration of the current measuring system.

3. Standardizing equipment must be maintained in working order and position and not be disassembled except for purposes of normal maintenance.

4. Basic parts of the standardization equipment must be compared against that of the National Bureau of Standards (or the National Research Council of Canada, if in Canada).

5. Standardization equipment must be inspected *in situ* by a physicist selected by the N B S or the N R C C.

6. Standardization equipment must be in accord with "X-ray Standards and Units Standardizing Procedure of the National Laboratories" (Am Jour Roentgenol and Rad Ther, 1934, 31, 815).

7. Laboratory must file with the N B S drawings showing all essential details of ionization chamber, tube container, and diaphragm system. Any subsequent changes must be filed with the originals.

In this connection, it should be noted that the physicist in charge of such standardization laboratories need not necessarily be a Registered Physicist, but that in any case his general qualifications must meet at least as high a standard thereas

The following laboratories have satisfied the necessary requirements under the above classification:

1. National Bureau of Standards, Washington, D C
Physicists Lauriston S Taylor, George Singer
2. National Research Council of Canada, Ottawa, Canada
Physicist G C Laurence
3. Cleveland Clinic, Cleveland, Ohio
Physicist Otto Glasser
4. Memorial Hospital, New York City
Physicists G Failla, Edith Quimby, Leo Marinelli
5. Temple University, Philadelphia, Pa.
Physicist George Henny
6. Victoreen Instrument Company, Cleveland, Ohio
Physicists John A. Victoreen, Lawrence Frazer

The above laboratories are certified to make calibrations for x-rays generated by potentials up to 200 kv (peak). There are at date of writing, no laboratories certified to make calibrations for x-rays generated by potentials in excess of 200 kv (peak). It is hoped that the National Bureau of Standards may be in such a position within a short time.

III Sub committee on Treatment Data Recording Charts (U V Portmann, Chairman, E C Ernst, Edith Quimby)—Final agreement was reached on a standard form for the recording of all treatment data. This will be published separately at an early date. With this will be published a full description of the entries with necessary details and precautions in making any measurements and calculations involved.

In addition, it is recommended that the radiologist in charge of an x-ray department maintain a day-book for recording all changes in tubes and apparatus, calibration changes, and calibration reports. It is suggested that all individual treatment records be initialed by technician and radiologist on such factors as filter, target-skin distance, and dose administered. This is particularly important for legal purposes.

In connection with the calibration of clinical x-ray installations, the importance of the field size used for the measurements was stressed. Particularly in the case of oil-immersed tubes and super-voltage tubes, it is

found that the dosage rate tends to increase with increase in field size. This is due principally to scattering from the large volume of oil. A sub-committee under Dr. Otto Glasser was appointed to prepare a report on this and related questions.

IV Sub-committee on Units, Definitions, and Nomenclature (R. R. Newell, Chairman)—A full report was deferred until the next meeting of the Committee. In the meantime, it was suggested that the Journal's Publication Committee refer any questions relating to units to Dr. Newell, who is representative of the Radiological Society on the Radiological Units Committee of the A. I. E. E.

V Sub-committee on Diagnostic Standardization—A detailed report was prepared by Dr. G. Henny, Chairman, but action relating thereto was deferred until the next meeting, before which time members may have a better opportunity to study his report.

VI Measurement of Super-voltage X-rays and Gamma Rays—The Committee feels that adequate measuring standards for super-voltage γ -rays and gamma rays are non-existent at this time. Work by Jaeger, Mayneord, Friedrich, Failla, Gray, and others is recognized as having great importance but not yet carried to the point where definite standards may be safely established. It seems evident that free air measurements will be impracticable for gamma rays.

Choice of the type of standard ionization chamber for super-voltage γ -rays should be very definitely left open for the present. Thimble chambers can undoubtedly be used for clinical purposes, although the ultimate correct design is open to question. Work by Glasser and by Victoreen up to 400 kv appears to contradict other equally reliable measurements of the so-called "saturation wall thickness." Four or five mm of bakelite or carbon wall thickness may be unnecessary and actually undesirable at lower voltages. They do not find strong evidence for the flat-topped wall-thickness curve. Hence, at least for super-voltages up to 400 kv, we may reasonably question some of the similar earlier work.

Open air ionization chamber measurements have been made up to 800 kv. Mayneord showed a definite divergence at about 250 kv, but this was due to use of too small a parallel plate chamber. Up to the point where his chamber size became the limitation, his measurements showed good agreement between open

air and thimble ionization. Lauritsen and Jaeger have shown that under suitable laboratory conditions free air chambers may be used for accurate measurements of super-voltage γ -rays. Hence, we feel that *thimble chamber standards should not be adopted for γ -rays until all the possibilities of free air measurements have been adequately explored.*

VII Filters for X-ray Treatments—The following approximate filter combinations are recommended by γ -ray treatment work:

Copper + 1 mm Al,

Tin + 0.25 mm Cu + 1 mm Al,

Lead + 1 mm Sn + 0.25 mm Cu + 1 mm Al

For the last two, it is desirable to have such a combination as to effectively cut off all wave lengths longer than 0.1 Å. In this connection, it is important to stop the passage of large amounts of radiation near the absorption limits of the particular filters used. Further details will be given in Dr. Glasser's later report.

VIII Quality—For clinical purposes, a statement of the fore-filter and half value layer gives an adequate quality description (fore-filter includes inherent filtration of tube and container). Use of a second half value layer is unwarranted. For fundamental and more accurate quality descriptions, the full absorption curve (or data) may be given. Only through the latter may other different quality measurements be related.

Quality measurements up to 400 kv shall be made with copper. It is recognized that while tin is more discriminating, the difference from copper is not important. Moreover, it is desirable to keep down the number of filter materials. Tin, in pure and uniform sheets, is not easily handled and its use may involve uncertain errors if special precautions are not taken. Lead absorption data are probably desirable above 400 kv but here again copper may possibly be sufficient for practical purposes.

The manufacturers shall be asked to give a statement with each γ -ray tube or the inclosure of the exact copper equivalence of the walls, and the voltage for which this applies. On permanent apparatus this may be marked on the apparatus itself.

IX Miscellaneous—It is suggested that the manufacturers provide "pre-reading" voltmeters with more open scales and more reliable calibration than is frequently done. Since the technician relies upon this meter so much

for control purposes, it is essential that the instrument be reliable and readable

Registered physicists, calibrating an x-ray plant, should see that all protection requirements are met, and report any omission to the radiologist in charge. A copy of such a report should be retained.

It is suggested that radiologists or hospitals installing new apparatus choose in advance the physicist who will do the subsequent calibration work. Advance consultation on apparatus, protection, and dosage measurement may be of great assistance to the radiologist and help to avoid expensive later changes.

Attention should be directed to the accurate timing of dosage. Errors in clock controls may be very considerable for short exposures of high dosage rate. The question of timers is being studied by Dr Weatherwax and Dr Chamberlain.

It was suggested that advance copies of this report be sent to members of the International Committee on Radiological Units and others interested.

LAWISTON S TAYLOR, *Chairman*

ADVISORY BOARD FOR MEDICAL SPECIALTIES

The annual meeting of the Advisory Board for Medical Specialties, which is the co-ordinating Board of the twelve certifying boards in the various specialties, the Association of Medical Colleges, the American Hospital Association, the Federation of State Medical Boards of the U S A., and the National Board of Medical Examiners was held at Atlantic City, N J., on June 6, 1937.

The following officers and members of the Executive Committee were elected:

Willard C Rappleye, M D, *President*, New York City, W P Wherry, M D, *Vice-president*, Omaha, Neb., Paul Titus, M D, *Secretary-Treasurer*, Pittsburgh, Pa., W B Lancaster, M D, Boston, Mass., and R C Buerki, M D, Madison, Wis., members of the Executive Committee.

Dr Louis B Wilson, of Rochester, Minnesota, the retiring president of the Board, was elected an emeritus member of the Board.

TAXING PROVISIONS OF THE SOCIAL SECURITY ACT

Delinquent employers of persons working in private x-ray laboratories were advised to-day by Commissioner of Internal Revenue Guy T Helvering to make immediate tax returns as required under the provisions of Titles VIII and IX of the Social Security Act to avoid further payment of drastic penalties which are now accruing.

Commissioner Helvering pointed out that every person working in private x-ray laboratories came under the provisions of Title VIII, which imposes an income tax on the wages of every taxable individual and an excise tax on the pay roll of every employer of one or more. This tax is payable monthly at the office of the Collector of Internal Revenue. The present rate for employer and employee alike is 1 per cent of the taxable wages paid and received.

Under Title IX of the Act, employers of eight or more persons must pay an excise tax on their annual pay roll. This tax went into effect on January 1, 1936, and tax payments were due from the employers, and the employers alone, at the office of the Collector of Internal Revenue on the first of this year. This tax is pay-

able annually, although the employer may elect to pay it in regular quarterly installments.

The employer is held responsible for the collection of his employee's tax under Title VIII, the Commissioner explained, and is required to collect it when the wages are paid the employee, whether it be weekly or semi-monthly. Once the employer makes the 1 per cent deduction from the employee's pay, he becomes the custodian of Federal funds and must account for them to the Bureau of Internal Revenue.

This is done, Mr Helvering said, when the employer makes out Treasury form SS-1, which, accompanied by the employee employer tax, is filed during the month directly following the month in which the taxes were collected. All tax payments must be made at the office of the Collector of Internal Revenue in the district in which the employer's place of business is located.

Penalties for delinquencies are levied against the employer, not the employee, the Commissioner pointed out, and range from 5 per cent to 25 per cent of the tax due, depending on the period of delinquency. Criminal action may be taken against those who willfully refuse to pay their taxes.

The employers of one or more are also required to file Treasury forms SS-2 and SS-2a. Both are informational forms and must be filed at Collectors' offices not later than next July 31, covering the first six months of the year. After that they are to be filed at regular

Actual money, when paid as wages, is not the sole basis on which the tax is levied. Goods, clothing, lodging, if a part of compensation for services, are wages and a fair and reasonable value must be arrived at and become subject to the tax.

Commissions on sales, bonuses, and premiums on insurance are wages and taxable.

Officers of corporations, whether or not receiving compensation, are considered employees for the purpose of taxation.

Wages paid during sick leave or vacation, or at dismissal, are taxable.

Travelling expenses required by salesmen are not wages if the salesmen account for, by receipts or otherwise, their reasonable expenditures. That part for which no accounting is made is construed as a wage and is taxable.

Exercise great care in filling out Treasury forms SS-1 and 940. Directions are easy to follow and correct returns mean no unnecessary delay.

quarterly intervals. Form SS-2 will show all the taxable wages paid to all employees and SS-2a the taxable wages paid each employee.

Participation in a State unemployment compensation fund, approved by the Social Security Board, does not exempt employers from the excise tax under Title IX, Commissioner Helvering said. Nor does the fact that there is no State unemployment compensation fund relieve the employer of his Federal tax payments. In those States where an unemployment compensation fund has been approved, deductions up to 90 per cent of the Federal tax are allowed the employer who has already paid his State tax. These deductions are not allowed unless the State tax has been paid.

This tax is due in full from all employers in States having no approved fund. The rate for 1936 was 1 per cent of the total annual pay roll containing eight or more employees, and for 1937 it is 2 per cent. The rate increases to

3 per cent in 1938 when it reaches its maximum. The annual returns are made on Treasury form 940.

An employer who employs eight or more persons on each of twenty calendar days during a calendar year, each day being in a different calendar week, is liable to the tax. The same persons do not have to be employed during that period, nor do the hours of employment have to be the same.

IN MEMORIAM

With profound sorrow The American Board of Radiology records the untimely passing of a distinguished fellow-member, Doctor Willis F. Manges, November 24, 1936.

Renowned as physician and radiologist, Doctor Manges logically was appointed to the Board at its inception. As a member of this body he served the interests of his chosen specialty with extraordinary fidelity and efficiency. Outstanding among his traits were his deep sincerity, absolute fairness, unimpeachable integrity, and remarkably sound judgment. Because he was wise, we looked to him for safe counsel, because he was eminently fair, we relied on him to make certain that no injustice was wrought by any act of ours, because he was steadfast, we counted confidently on his unflinching friendship. So long as we shall live his memory will abide with us, and through the years to come radiology and radiologists will reap the benefit of his unselfish work in their behalf.

It is ordered that this declaration be spread on the minutes, that it be published in the radiologic journals, and that the Secretary of the Board transmit a copy to Mrs. Manges with assurance of our heartfelt sympathy and respect.

A. C. CHRISTIE, *President*
B. R. KIRKLIN, *Secretary*

June 3, 1937

BOOK REVIEWS

REPORTS OF THE SECOND INTERNATIONAL CONGRESS OF SOCIAL AND SCIENTIFIC CAMPAIGN AGAINST CANCER, Brussels, Belgium, Sept. 20-26, 1936, under the patronage of His Majesty the King and Her Majesty Queen Elizabeth. Volume I, General Reports, published under the direction of M^{lle} Docteur Marta Fraenkel. A volume of

503 pages Published by Ligue Nationale
Belge contre le cancer, Brussels, 1936

This is a series of reports by specialists, each outstanding in his particular field, on the modern views of the etiology, diagnosis, treatment, and prevention of various types of malignant tumors. Each paper is reproduced in full in the language of the author and summarized in German, English, Spanish, French, Italian, and Russian. The table of contents of the volume is as follows:

(A) *Scientific Cancerology*

I *Biology*

- 1 Carcinogenic agents
 - Cook, J W, Haslewood, G A D, Hewitt, C L, Hieger, I, Kennaway, E L, and Mayneord, W V (London) Chemical Compounds as Carcinogenic Agents (report in English) 1
 - Borst, M (Munich) Organic Substances of Growth (German) 24
 - Murphy, J (New York) Inhibition of Malignant Growth by a Factor from Normal Tissue (English) 43
 - Gye, W E (London) Tumors Transmissible with Viruses 48
 - Pentimalli, F (Florence) Transmissible Carcinogenic Agents (report in Italian) 59
 - Roffo, A H (Buenos Aires) Physico-chemical Etiology of Cancer (report in Spanish) 71
 - Vles, F (Strasbourg), and de Coulon, A (Lausanne) Study of Various Physical and Physico-chemical Carcinogenic Factors (report in French) 88
- 2 Factors of predisposition and of resistance to carcinogenesis
 - Kreyberg, L (Oslo) Genetic Factors in the Development of Spontaneous and Induced Tumors in Animals (report in English) 115
 - Lynch, C (New York) Present Aspects of Cancer in Relation to Heredity (report in English) 122
 - Fischer-Wasels, B (Frankfort-on-Main) General Predisposition to Cancer (report in German) 133
 - Reding, R (Brussels) Predisposition and Resistance to Cancer (report in French) 159

Teutschlaender, O (Mannheim)
Humoral Regulations and Tumoral
Formations (report in German) 205

II *Diagnosis*

- 1 Progress in histological diagnosis and prognosis
 - Ewing, J (New York) Problems in Histological Tumor Diagnosis (report in English) 215
- 2 Progress in serological and sero-cytological diagnosis
 - Hirsfeld, L (Warsaw) On the Scientific Bases of the Serodiagnosis of Cancer (report in German) 227
 - Del Rio Hortega, P, and Ibanez, R (Madrid) Recent Research Work on Serological and Sero-cytological Diagnosis of Cancer (report in Spanish) 240
 - Rondoni, P (Milan) Critical Study on Recent Experiments on Serological and Sero-cytological Diagnosis of Cancer (report in Italian) 262

III *Therapeutics*

- 1 Progress in surgical treatment
 - Hartmann, H (Paris) Progress in Surgery in the Treatment of Cancer (report in French) 277
 - Petroff, N (Leningrad) Recent Progress in the Surgical Treatment of Rectum Cancers (report in Russian) 292
 - Dogliotti, A (Modena) Treatment of Pains from Tumors (report in Italian) 309
- 2 Progress in radiotherapy
 - Wood, Francis Carter (New York) Progress in X-ray Therapy (report in English) 320
 - Schinz, H R (Zurich) Progress in X-ray Therapy (report in German) 331
 - Mallet, L (Paris) Tele-x-ray-therapy of cancers (report in French) 334
 - Holthausen, H (Hamburg) X-ray Radiobiology (report in German) 352
- 3 Progress in medical treatment
 - Auler, H (Berlin) Chemotherapy of Malignant Tumors Its Physico-chemical Bases (report in German) 361

- Blumenthal, F (Belgrade) Organotherapy of Cancer (report in German) 379
- Maisin, J, and Pourbaix, Y (Louvain) Organoprophylaxy (report in French) 389
- Freund, E (Vienna) Diets and Cancer Treatment (report in German) 407

(B) *Social Campaign against Cancer*

- I *Access of patients to diagnosis and treatment*
- Athias, M (Lisbon) General Organization of the Anti-cancer Campaign (report in French) 419
- Lerat, P (Brussels) Social Principles of the Campaign against Cancer (report in French) 427
- Sand, R (Brussels) Social Medicine and Anti-cancer Campaign (report in French) 430

II *Medico-social assistance to the incurables*

- Le Bret, R (Paris) Medico-social Assistance to the Incurables (report in French) 435

III *Cancer and demography*

- 1 Statistics of morbidity and mortality of cancer
- Cramer, W (London) The Importance of Statistical Investigations in the Campaign against Cancer (report in English) 441
- Dormanns (Munich) Comparative Statistics on Geographical Distribution of Cancer in the Reich over the Period 1925 to 1933 (report in German) 460
- Dublin, L (New York) Statistics on Morbidity and Mortality from Cancer in the United States (report in English) 483
- 2 Cancer and races
- Bonne, C (Batavia) Cancer and Human Races (report in English) 492

l'Academie de medecine, chirurgien de l'hôpital des Enfants-malades, and P MATHIEU, Professeur de clinique de chirurgie orthopedique de l'adulte à la Faculté de medecine de Paris, chirurgien de l'hôpital Cochin Volume III Published by Masson et Cie, Paris, France, 1937 Price, for five volumes complete, 1250 fr

The third volume of this System of Orthopedic Surgery seems to me to be by far the best of the three volumes thus far reviewed and has set a high standard for such a work

After a chapter on tumors of the spine which covers those lesions in a comprehensive manner the remainder of the volume is taken up with a discussion concerning the upper extremity Starting with the scapula and going down to the hand and fingers, each anatomical part is treated separately but a complete discussion of the various lesions affecting those parts is given All are excellently illustrated and fully covered, with little in the way of superfluous discussion Much of these chapters concerns fractures and their complications and sequelæ This seems reasonable, as the importance of fractures of the arm and particularly those around the elbow cannot be over-estimated

Adequate discussion is given to the congenital lesions such as elevation of the scapula, club hand, Madelung's deformity, etc The work will serve as a most excellent reference book for those seeking information on any of these subjects

One of the most complete and best presented reviews of the subject of injuries of the carpus that I have ever seen is found here The common inflammatory lesions are covered adequately, too, and treatment as well as diagnosis and prognosis is well outlined

Several types of treatment of these various lesions are presented Many are unfamiliar to the reviewer but look worthy of application

The volume is excellently illustrated by photographs, roentgenograms, and by drawings as necessary Beautifully printed, it has, along with the other volumes, set a high standard in that respect The material and its arrangement in this volume seems to us most excellently conceived and, as we have already said, it has set a high mark for others to reach

TRAITE DE CHIRURGIE ORTHOPEDIQUE By
L OMBREDANNE, Professeur de clinique
chirurgicale infantile et orthopedie à la
Faculté de medecine de Paris, membre de

ABSTRACTS OF CURRENT LITERATURE

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S M ATKINS M D, of Waterbury Conn	ERNST A POHLE M D Ph D of Madison Wis
G E BURCH M D, of New Orleans La	WILLIAM R STECHER M D of Easton, Pa
L G JACOBS M D of Madison Wis	CHARLES G SUTHERLAND M B (Tor) of Rochester, Minn
E T LEBBY M D of Rochester Minn	JOHN C WHITELEATHER M D of Memphis Tenn
DAVIS H PARDOLL M D of Chicago Ill	

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ANIMAL EXPERIMENTATION

Röntgen Therapeutic Experiments in Erythrocytosis of the Chicken E. Gorfota *Strahlentherapie*, 1937, 58, 295

Leukemia in chicken occurs in two different types, one contagious and one non contagious type. The lymphadenosis cannot be transferred to other animals and this is the most frequent type. The myelosis however, and especially the erythrocytosis can be transferred from animal to animal. The author used finely mashed liver of a chicken which had died from the disease dissolved in 10 per cent physiological sodium chloride solution and injected from 0.5 to 1 cc intravenously in healthy chickens. Seventeen out of 18 developed the disease. He then studied the effect of roentgen rays on its course. Technique 150 kV, 50 cm FSD total body exposure with from 80 to 180 r, with aluminum and copper filtration, exposures were given on the sixth and ninth day or every second day. The course of the disease was unaltered in the irradiated animals. The virulence of the contagion was also the same whether taken from untreated controls or treated chicken. This was checked through to the fifth generation. It appears, therefore, that the erythrocytosis in chicken is far more resistant than leukemia diseases in man.

ERNST A. POHLER, M.D., Ph.D.

Changes in the Spinal Fluid in Animals Following Short Wave Therapy to the Brain R. Glauner and E. Schorre *Strahlentherapie*, 1937, 58, 286

The authors applied a six meter wave to the head of rabbits by means of Schleichplate electrodes of 4 cm diameter at 1 cm distance. The single application lasted 30 minutes and a total of 10, 15 and 20 sittings were given. Following this therapy definite chemical changes were found in the spinal fluid. The proteins and the sugar content were increased. These changes were maintained for a long period of time up to 30 weeks. There seems to be a relation between the dose and the effect.

ERNST A. POHLER, M.D., Ph.D.

THE BLADDER

Diverticulum of the Urinary Bladder Neil S. Moore *Southern Med Jour* March 1937, 30, 263-267

From an evaluation of this brief analysis it is apparent that the author held the following conclusions. In addition to the indisputable theory of congenital tendency to urinary diverticulosis the exciting causative factors are contracted bladder necks and hypertrophy of the prostate. Statistics of individual physicians may vary according to the type of work done. The diagnosis is comparatively simple if routine cystoscopic and cystographic examinations are made. Small buds single or multiple will probably remain stationary if the obstructing lesion is removed by trans-

urethral methods. If, however, the bladder is opened by suprapubic incision, it is advisable to remove all pockets at the same time.

Large diverticula should certainly be removed. The most satisfactory method is complete external excision working through the opened bladder with a finger inserted into the collapsed sac as a guide. Spinal anesthesia in moderate sized doses, seldom exceeding 100 mg of procaine hydrochloride has been of material benefit in allowing complete relaxation and ample exposure of the operative field. In careful hands and with average good fortune spinal anesthesia is the safest of all anesthetic agents in bladder surgery. Ample drainage of the bladder and all dependent pockets will reduce morbidity and mortality.

A rather extensive bibliography accompanies the article.

DAVIS H. PARDOLL, M.D.

Management of Atonic Bladder Due to Obstruction of Vesical Neck Louis M. Orr, II *Southern Med. Jour*, May, 1937, 30, 519-524

While in recent years much has appeared in the literature on cord bladder there has been a paucity of information on this particular subject as viewed by the writer.

Regardless of the type of method employed in eliminating the obstruction, atonicity may persist due to a loss of elasticity in the vesical musculature. The author advocates partial resection of this inelastic area in order to correct the loss of tone and to relieve the retention of urine.

A case presentation, cystograms and discussion accompany this interesting article.

DAVIS H. PARDOLL, M.D.

BONE DISEASES (DIAGNOSIS)

Sunray Hemangioma of Bone William E. Anspach *Jour Am Med Assn* Feb 20 1937, 108, 617-620

Only 21 cases of hemangioma involving the skull have been found in the literature. Of 1,831 neoplasms of bone recorded at the bone registry 13 have been hemangiomas. Three of these involved the skull. Earlier reports failed to distinguish hemangioma from sarcoma the 'sunburst' appearance on roentgenograms apparently largely responsible for the error in interpretation.

The tendency for hemangioma of bone to produce a somewhat characteristic picture on roentgenograms seems to be due in part to the type of bone involved. It should be considered in all "sunburst" tumors of bone, but a malignant neoplasm should be considered equally probable when there is a sunray pattern on roentgenograms of long bones especially if there has been active destruction of bone. Sharply defined well organized trabeculae or spicules favor hemangioma.

Hemangioma of flat bones produces a beautiful sunray

formation on roentgenograms Hemangioma of long bones often produces a "loose soap bubble" appearance but almost as frequently the sunray pattern of density When hemangioma involves vertebrae, a vertical striated appearance is produced which is almost characteristic of this one type of tumor

CHARLES G SUTHERLAND M B (Tor)

THE BREAST (BENIGN)

Roentgen Therapy of Puerperal Mastitis R Goedel. *Strahlentherapie*, 1937, 58, 651

The author has used the following technic in the treatment of puerperal mastitis 170 kv, 3 ma, 30 cm F S D, 0.5 mm Cu, 50 r surface dose, to be repeated on three or four successive days The best results were seen if the treatment was started within 12 hours after the symptoms appeared Twenty nine out of 30 cases of acute mastitis or 97 per cent, healed without incision following radiation therapy

ERNST A POHLE, M D, Ph D

CANCER (DIAGNOSIS)

Experience with the Klein Reaction. G Hepp München med Wchnschr, Aug 21 1936, 83, 1378-1380

In an open series of cases, there was a percentage of 93.4 correct diagnoses, as contrasted with 90.2 per cent confirmation in the unknown series The test does not differentiate carcinoma from sarcoma Excellent results were obtained in differentiating prostatic hypertrophy from prostatic carcinoma, and mastopathia chronica cystica from mammary carcinoma

WILLIAM R STECHER, M D

Experiences with the Klein Cancer Reaction C Reimers München med Wchnschr Aug 21, 1936, 83, 1375-1377

In the writer's experience with the Klein reaction for the detection of malignancy over a period of two years, he has found it correct in 90 per cent of his cases, when positive, and even higher when malignancy was not present

WILLIAM R STECHER, M D

Experience with the Carcinoma Demonstration Serologic Test of Lehmann Facius H Reploh and H Middledorf München med Wchnschr, Aug 21 1936, 83, 1380, 1381

In their series of 350 cases, in which 100 presented clinical signs of carcinoma or sarcoma the Lehmann-Facius reaction gave 94 per cent positive results, and 4.2 per cent unspecific results.

WILLIAM R STECHER, M D

Experience with the Klein Test Fritz Grögler München med Wchnschr, Aug 21, 1936 83, 1377, 1378

In 90 cases in which the Klein test was employed, in which malignancy was suspected, 92.6 per cent showed a positive reaction which was confirmed clinically later

WILLIAM R STECHER, M D

CANCER (THERAPY)

Contact Therapy Strahlentherapie, 1937, 58, 606-623

Six authors contributed to a discussion of contact therapy *i.e.*, the treatment by means of an x ray tube which can be introduced into the body cavity and brought into contact with the lesion

W Schaefer (p 606) has used it in the treatment of carcinoma of the cervix An observation period of from six months to three years, of 88 patients shows that the results so far have been encouraging The statistical evaluation still suffers from the fact that the number of patients treated is relatively small

W Weibel (p 609) gives also the preliminary results obtained at the Women's Clinic of the University of Vienna with the use of contact irradiation in carcinoma of the female generative organs His total material comprises 56 cases which includes 38 patients with inoperable carcinoma of the cervix The immediate results up to an observation period of one year were very satisfactory

H Chaoul (p 611) reports excellent results obtained in the treatment of carcinoma of the skin and the lip, and also in malignant melanomas Quite satisfactory response was also seen in carcinoma of the oral cavity, glandular organs, and carcinoma of the rectum, and in sarcoma The patients have been under observation from one to five years and out of a total of 307 cases, 76 per cent were free from symptoms at the time of the report Forty-five patients were treated more than three years ago and 14 of those more than four, and three of those more than five years ago

F Melchart (p 614) believes that the future development of contact therapy will be along the lines of further approach to radium The economic side is, of course, of great importance since roentgen therapy with the contact method is less expensive than radium treatment

A Frank (p 618) has used the method for a year and a half and reports a few illustrative cases In addition to malignant tumors, he also treated two patients with hemangioma of the buccal mucosa, their lesions reduced in size after the application of 6,000 r He feels that the contact method can be used successfully in many cases which otherwise would have to be treated by radium

P Merno (p 623) has treated 12 cases with malignant neoplasms with contact therapy, applying doses of from 6 000 to 12 800 r The temporary results in five cases were good

ERNST A POHLE, M D, Ph D

The Co-operation of Surgeon and Radiologist in the Treatment of Tumors of the Upper Respiratory and

Digestive Tracts Considered from the Roentgenological Viewpoint E G Mayer *Strahlentherapie*, 1937, 58, 636

In many instances operative procedures facilitate adequate irradiation of malignant tumors. The author mentions the advantage of tracheotomy and resection of the thyroid cartilage in the treatment of carcinoma of the larynx, gastrostomy in irradiation of the stomach and provision of adequate drainage in carcinoma of the sinuses before radiation therapy.

ERNST A. POHLE, M D, Ph D

Histologic Changes in Cutaneous Cancer Following Irradiation Paolo Gerotoli *Archivio di Radiologia* 1936 12, Nos 3-4, 221-213

The author studied histologically some sections taken from cutaneous ulcerated carcinomas at various intervals following treatment with various doses and qualities of radiation. The histologic picture is variable, with the exception of the eosinophiles, which are more numerous when the reaction is more severe, and of the fat droplets, which seem to be independent of time and the number of irradiations.

F T IDON, M D

Methods of Radiation Therapy of Cancer with Extremely High Potentials A Gunsatt *Strahlentherapie* 1937, 58, 573

The author describes his 800 kv generator used in the treatment of cancer and gives data regarding output and the effect of potential, filter and field size on the depth dose, amount of back scatter, and the skin reactions to be expected. The increase in the depth dose amounts to 30 per cent if the tube potential is increased (from 200 to 520 kv). The amount of back scatter is definitely reduced, it is possible therefore, to apply larger doses to the skin. The field of usefulness for these extremely hard rays is perhaps limited to deep seated malignancies.

One interesting observation concerns the changes in the blood picture when comparing 200 and 520 kv radiation. Patients treated with the shorter rays showed a higher absolute drop in leukocytes and also a rather striking increase of the sedimentation velocity of the erythrocytes. The author is optimistic regarding the future of high voltage therapy. He believes that within a relatively short time the cost of this type of apparatus will become low enough so that its general use will be possible.

ERNST A. POHLE, M D, Ph D

Fractional and Protracted Fractional Radiation Therapy Experiences at Zurich H R Schinz *Strahlentherapie* 1937 58, 373

The author relates his experience with the fractional method in the treatment of malignant tumors based on an analysis of 800 cases seen during the period 1919-1935. He believes that irradiation of malignant neoplasms is local treatment. The tumor must receive a lethal dose,

the effect of irradiation is direct both upon the cancer cell as well as on the blood vessels in the tumor. It is important to utilize the elective effect of irradiation *ie*, use the difference in sensitivity between cancer tissue and normal tissue to radiation. The total dose should be applied in as short a time as feasible rather than to give several series at long intervals. A number of illustrative cases are discussed with detailed data regarding dosage. The methods used are simple fractionation and protracted fractionation with high intensities and simple fractionation and protracted fractionation with very small intensities.

In a series of tables the results obtained in the treatment of the various tumors are evaluated statistically. There is no question but that the Coutard method using protracted fractionation with a small number of *r* per minute brings about clinical cures which are impossible with other methods of application. Radium implantation or electrocoagulation are used in this connection only to remove small residual masses or small recurrences. The author believes that with this method of treatment his results are as good as those obtained in other institutions having available large quantities of radium.

ERNST A. POHLE, M D, Ph D

THE COLON

Roentgenographic Studies of the Mucous Membrane of the Colon III—Mucosal Detail Studies as an Aid in the Early Recognition of Carcinoma of the Colon Henry G Jacobi and Franz J Lust *Am Jour Med Sci*, April, 1937, 193, 510-515

The use of mucosal detail study of the colon for small and early organic lesions has been neglected in this country though the method has been used abroad with apparent success. The authors present their method of study of the mucous membrane of the colon which has proved satisfactory in their patients. The procedure is as follows. The first essential for the proper execution of this method is to have as clean a colon as is possible. To effect this the preparation of the patient begins a day previous to the actual examination, during which time only a slight low residue diet is allowed. In the evening before the examination a dose of milk of magnesia or cascara is given. The following morning two enemas containing about a quart of water with some Castile soap are used at one-hour intervals. From two to three hours after the last enema the patient is ready for examination. A cup of tea or coffee may be allowed in the morning but nothing else. The barium enema itself consists of about one quart of barium mixture prepared in plain water. No milk or mucilage is to be used in the preparation of this solution as such tends to delay the evacuation of the colon.

The slow administration of the barium enema is then started under proper fluoroscopic control in order to detect the presence of stenosing lesions immediately. As soon as the tip of the contrast material has reached

the hepatic flexure of the colon it is discontinued. The patient is then instructed to turn on his right side. Very often the barium will fill out the cecum without giving more barium. Too much contrast material, if administered, will not only cause distress but in many cases results in leakage into the small intestine. When this has occurred, the subsequent evacuation of the large bowel upon which the success of this method depends will be seriously hindered and will make proper mucosal study almost impossible. A film is then taken with the patient lying on his abdomen. The patient is then instructed to evacuate as much of the barium enema as possible. Repeated fluoroscopic examination is then made to determine whether the correct amount of barium is present to outline the mucosal wall. Sometimes the period of evacuation may take from 30 to 45 minutes. Naturally, no technician can be entrusted with this procedure."

Three cases are reported in which the 'mucosal detail' method proved of service in making an early diagnosis of an organic lesion of the colon which had previously been unobserved by the routine barium enema. The authors feel that with the early diagnosis of colon malignancy by such a method one can expect better therapeutic results than obtained in the past.

G E BURCH M D

COUTARD METHOD

Roentgen Injuries of the Parotid Gland H H Hermann *Strahlentherapie*, 1937, 58, 220

The parotid gland of a patient with carcinoma of the pharynx showed histologically lipomatosis and loss of the glandular structure following irradiation according to the Coutard method. In order to determine the causal relation between the roentgen exposure and the histologic change the author irradiated the parotid glands of 11 rabbits (180 kv 0.5 mm Cu + 1.0 mm Al 40 cm FSD). Doses of from 1,600 to 5,000 r were applied. Five animals were treated over one parotid at one sitting, two with the fractional dose method and two with the Coutard method—the same as the patient. The microscopic studies of the glands indicated that irradiation was not responsible for the lipomatosis. The acute reaction within the gland, swelling, dry mouth, and edema of the face is temporary. Little difference was noted between the reactions in glands treated with simple fractionation and according to Coutard. Injury to the parotid glands seemed to be more likely with the protracted fractional dose method. From an economical standpoint simple fractionation is undoubtedly preferable.

ERNST A POHLE M D Ph D

THE CRANIUM

Auxiliary Methods in the Diagnosis of Space-occupying Intracranial Diseases Hugo Krayenbühl *Schweiz med Wchnschr* Jan 30 1937, 65, 89-94

The author mentions as necessary supplements to clinical examination roentgen study of the skull, ventriculography and encephalography, exploratory ventricular puncture, and cerebral angiography.

Roentgen study of the skull may show abnormal calcification, displacement of normally calcified pineal gland, choroid plexus, or falx, or of air shadows. Especially important are changes in the skull bones known to be associated with tumors.

Ventriculography and encephalography have the great advantage that practically every space-occupying lesion produces a displacement of the ventricular system. The type of lesion cannot in general be ascertained from a ventriculogram. It shows only changes from normal in form and size of the ventricles. Encephalography is indicated in cases without clinical evidence of risk of brain stem herniation, usually focal and general epilepsy, as well as certain cases of chronic hydrocephalus.

Exploratory ventricular puncture is indicated in cases in which one wishes to verify the neurologic diagnosis, it is the method of choice in cases of coma and in cases in which the pressure changes preclude ventriculography. While the interpretation is beset with pitfalls it may make possible a life saving operation.

Cerebral angiography is especially valuable in vascular intracranial lesions, as aneurysms and in the diagnosis of tumors by the changes they produce in the vascular bed. Displacement of vessels may be observed.

Illustrative cases, some good drawings, and some fair reproductions of roentgenograms are included.

L G JACOBS, M D

ENDOCRINE GLANDS

The Relation of the Endocrine System to Malignancy Charles L Martin *Am Jour Roentgenol and Rad Ther*, September 1936, 36, 314-321

The secretions from certain organs in the body, especially the spleen, thymus, thyroid and adrenal glands seem to exert an antagonistic effect on the growth of malignant tumors. The secretions from the ovary seem to favor the growth of benign tumors in the uterus and breast and malignant tumors in the breast.

No effective gland extracts for the eradication of cancer have as yet been prepared, but the withdrawal of the ovarian hormone by castration produces marked benefit in certain advanced cases of cancer of the breast, especially those with bone metastases. Pain is often relieved and bone metastases improved by new bone replacement. Cases are cited.

S M ATKINS M D

THE EYE

Effect on the Eye of Radium Used for Treatment of Malignant Disease in the Neighborhood Philippa Martin *British Med Jour*, March 27, 1937, 651-654

The author observing the changes produced in the

eyes when radium was used in their vicinity under took to study the radium injuries to the eyes

Radium when employed near the eyes in treating malignancies damaged the conjunctiva iris cornea, and lens. The conjunctival irritation is manifested early by congestion, edema and a serous discharge or a mucopurulent discharge at times. Pain is not frequent even in a severe conjunctival reaction. Some of the late conjunctival effects are scarring, adhesion to the globe and lids and ectropion.

The iris may be affected and the involvement evidenced by pain, slight swelling of the iris and posterior synechia.

The chief manifestation of damage to the cornea is ulceration. This may result from the direct action of irradiation or may result indirectly as from dryness of the cornea caused by reduced lachrymal activity from irradiation. Exposure of the cornea when the lids are kept open by chemosis resulting from the conjunctivitis may also cause ulceration. Diminution in sensation in the cornea is one of the earliest signs of damage. Later there is a loss of the normal corneal luster. The ulcers may progress to perforation with the resulting complications.

Radium cataract is another late reaction to irradiation, and appears two years or more after exposure. This probably arises from interference with the nutrition of the lens caused by endarteritis and telangiectatic changes in the ciliary body.

The author discusses the causes of such ocular complications in irradiation therapy to malignancies in the vicinity of the eyes and also presents the methods for avoiding or minimizing such undesirable results.

G. E. BURCH, M.D.

THE FIBULA

A Rare Luxation Isolated Luxation of the Fibular Head Anteriorly G. Imhäuser München med Wehnschr, Aug 21, 1936 83, 1383-1384

It is not unusual to have associated luxation of the fibular head with a fracture of the fibula, but a luxation *per se* is very rare. The literature is reviewed, and an additional case is proffered. Roentgenographically the diagnosis is simple in a typical case.

WILLIAM R. STECHER, M.D.

FOREIGN BODIES

Osseous Bridging of Vertebral Bodies Resultant of a Foreign body Abscess Ulrich München med Wehnschr Dec 11 1936 83, 2049-2050

A brief but excellent review of the two main types presenting osseous bridging of the vertebral bodies is presented and differential diagnostic roentgenologic features are stressed. These types are namely Bechterew's disease and spondylo-arthritis deformans.

The author presents another etiologic factor causing somewhat analogous signs which are secondary to ir-

ritative reaction of a pre vertebral abscess, due to lodging of a metallic foreign body. This is rather rare, for commonly such a circumstance produces pressure atrophy of vertebral bodies due to transmitted pulsation of the aorta. The main reason that a diagnosis of Bechterew's disease was not made was the restriction of the osseous bridging to the site of the abscess.

WILLIAM R. STECHER, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

Cholecystographic Findings Following Cholecystostomy L. L. Jenkinson and Joseph M. Foley Am Jour Roentgenol and Rad Ther, September 1936, 36, 301-304

Cholecystostomy does not necessarily leave a pathologic gall bladder behind as previous authors concluded for of 28 patients who had had their gall bladders surgically drained from eight months to many years before 19 or 68 per cent showed a normal functioning with the dye (Kiaphen B) examination.

S. M. ATKINS, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Duodenal Diverticula Walther Thaler München med Wehnschr, Dec 11, 1936 50, 2055-2058

Duodenal diverticula may be symptomless or present symptoms if marked stasis of food occurs, with ensuing diverticulitis, hemorrhage, abscess formation, gangrene and perforation. The lack of muscularis and peristalsis in the diverticulum predisposes to retention particularly in the presence of a narrow neck. The presence of a diverticulitis by direct extension is productive of gastritis, duodenitis, pancreatitis and cholangitis, cholecystitis and hepatitis. In addition pressure symptoms on neighboring organs by a filled diverticulum may be the only symptoms. The incidence as shown roentgenologically is from 1.2 to 1.7 per cent but anatomically 3 to 13 per cent is found. In the author's series of 1,100 gastro-intestinal examinations 1.5 per cent showed duodenal diverticula. The most common site is the descending portion of the duodenum particularly in the vicinity of the papilla of Vater and almost always in the concavity of the duodenal loop. The size varied from that of a lentil to a small apple, and oddly in this series a predominance of females presented diverticula with occasional double diverticula. Clinical symptoms are vague but summed up as follows: (1) Symptoms are improved in certain postures and by massage, (2) symptom of dullness are almost constant and of long standing, (3) gaseous gastric eructations, nausea, loss of appetite, flatulence, constipation and loss of weight are common findings. However in any non-typical gastric disturbance a roentgenologic examination is indicated and these are readily noted if a careful examination in horizontal and vertical positions with exposures in many planes are obtained. Roentgenologic criteria are briefly: (1) A well-defined density with

sharply circumscribed contour, in the confines of the duodenum (2) a portion of the barium passes over, or beside, the suspicious density, showing the site of the neck of the diverticulum, (3) the contrast fleck remains after emptying of the duodenal loop, (4) hours to days, occasionally show retention of barium in the diverticulum, (5) absence of tenderness, when no diverticulitis is present, suggests a diverticulum rather than an ulcer niche, (6) in compression technic the mucous membrane pattern is visualized in contradistinction to an ulcer crater loss of outline.

Treatment is mainly conservative, and along the lines of peptic ulcer. If ineffective, surgical removal is then considered.

WILLIAM R. STECHER, M D

Polypoid Tumors of the Duodenum and Small Intestine Ferdinando Taha and Pasquale Ficara *Archivio di Radiologia*, 1936, 12, Nos 3-4, 190-220

Taha and Ficara first discuss the incidence of polypoid gastro-intestinal tumors which are commonest in the rectosigmoid and rarest in the stomach and upper intestine. The symptomatology and clinical findings permit the holding of only a tentative diagnosis of polyp. It is only by roentgenologic examination that diagnosis can be made with precision. Some characteristic cases are illustrated. The authors favor surgical treatment of polyps because of the possibility of malignancy in them. The paper is accompanied by a good bibliography.

E. T. LADDY, M D

GYNECOLOGY AND OBSTETRICS

Is It Possible to Injure the Genes in the Reproductive Organ of Women by Radium and Roentgen Rays? C. Weysser *Strahlentherapie* 1937, 53, 470

The relation between irradiation by roentgen rays or radium of the female pelvis and injury to the future offspring is still a matter of debate. The author reports two illustrative cases belonging to this group. One woman, 32 years of age, was treated over the abdomen for actinomycosis. The right ovary was in the beam and the left ovary could not be entirely protected. Roentgen rays were applied according to the Coutard method with a total dose of 2300 r. Three months after the treatment the patient was cured. Five months later she became pregnant and delivered a normal child weighing 3 kg. The second patient had been treated by intra uterine radium screens because of tuberculosis of the uterus (1,200 mg hr., 50 mg in 1 mm Al for 24 hours). The ovaries were of course included in the irradiated area. However, the woman became pregnant again six months later. The child was born six weeks after term and was dead at birth. The delivery was difficult because of stenosis of the cervical canal. The fetus appeared normal and weighed 3.450 grams.

The author does not believe that there is a direct connection between irradiation and death of the child.

Whether the abnormal length of the pregnancy was due to the radium treatment is impossible to state. He concludes that in his opinion there has been no proof offered yet that roentgen and radium irradiation of women in the child bearing period will injure the genes.

ERNST A. POHLE, M D, Ph D

The Diagnosis of Tubal Pregnancy Albert Mathieu *Jour. Am. Med. Assn.*, Jan 30, 1937, 108, 366-369

There is probably no more dramatic incident in the life of a physician than that of the text book type of ruptured tubal pregnancy. Those cases with the typical history represent only a small percentage. The others, not typical, are at times very difficult to diagnose. The diagnosis cannot be made unless the physician has the condition in mind. He must remember that any vaginal bleeding in the child bearing age, following a missed period, may possibly mean an ectopic pregnancy. Discussion is limited almost entirely to the diagnosis and among the more or less unusual diagnostic methods the author reports practically 100 per cent correct diagnoses from hysterosalpingography in the several cases in which it was used. The abortion of the tubes was beautifully visualized, and he was able to establish what seems to be a pathognomonic x-ray sign for a tubal pregnancy in the midportion of the tube. In cases of tubal pregnancy aborting from the distal end of the tube the injected oil entered all the crevices between the aborting pregnancy and the walls of the distal ends of the tubes in such a way that it literally draped itself about the mass and allowed this oil-covered mass to be visualized by the x-rays. The injection into the uterus and tubes of iodized oil in a case of tubal pregnancy he considered practically harmless.

CHARLES G. SUTHERLAND, M B (Tor)

HEART AND VASCULAR SYSTEM

Situs Inversus of the Abdominal Organs with Congenital Heart Failure and Right Aortic Arch H. Grieshaber *Schweiz. med. Wchnschr.*, Dec 26, 1936, 52, 1307, 1308.

The author presents an excellently studied case of situs inversus of the abdominal organs, with persistent right aortic arch, and ventricular septal defect with incomplete rotation of the heart. The one significant roentgenologic sign for future diagnostic aid is the fact that the author proves that the position of the diaphragm is not resultant of pressure displacement of the liver but rather to the position of the heart. Thus in primary cases of dextrocardia the left diaphragmatic cupola is on a plane with the right. Pathognomonic signs of right aortic arch are given, namely absence of aortic knob and pulsation to the left, indentation of the esophagus along the dorsum, and the fact that the triangle to left of the superior aspect of the tracheal bifurcation is missing. Excellent clinical discussion relevant to differentiation of the various types of congenital cardiac malformations is appended.

WILLIAM R. STECHER, M D

eyes when radium was used in their vicinity, undertook to study the radium injuries to the eyes.

Radium when employed near the eyes in treating malignancies, damaged the conjunctiva, iris, cornea, and lens. The conjunctival irritation is manifested early by congestion, edema, and a serous discharge or a mucopurulent discharge at times. Pain is not frequent even in a severe conjunctival reaction. Some of the late conjunctival effects are scarring, adhesion to the globe and lids and ectropion.

The iris may be affected and the involvement evidenced by pain, slight swelling of the iris and posterior synechia.

The chief manifestation of damage to the cornea is ulceration. This may result from the direct action of irradiation or may result indirectly as from dryness of the cornea caused by reduced lachrymal activity from irradiation. Exposure of the cornea when the lids are kept open by chemosis resulting from the conjunctivitis may also cause ulceration. Diminution in sensation in the cornea is one of the earliest signs of damage. Later there is a loss of the normal corneal luster. The ulcers may progress to perforation with the resulting complications.

Radium cataract is another late reaction to irradiation and appears two years or more after exposure. This probably arises from interference with the nutrition of the lens caused by endarteritis and telangiectatic changes in the ciliary body.

The author discusses the causes of such ocular complications in irradiation therapy to malignancies in the vicinity of the eyes and also presents the methods for avoiding or minimizing such undesirable results.

G. E. BURCH, M.D.

THE FIBULA

A Rare Luxation Isolated Luxation of the Fibular Head Anteriorly. G. Imhäuser München med Wehnschr, Aug 21 1936 83, 1383-1384.

It is not unusual to have associated luxation of the fibular head with a fracture of the fibula, but a luxation *per se* is very rare. The literature is reviewed, and an additional case is proffered. Roentgenographically the diagnosis is simple in a typical case.

WILLIAM R. STECHER, M.D.

FOREIGN BODIES

Osseous Bridging of Vertebral Bodies Resultant of a Foreign Body Abscess. Ulrich München med Wehnschr, Dec 11, 1936 83, 2049-2050.

A brief but excellent review of the two main types presenting osseous bridging of the vertebral bodies is presented and differential diagnostic roentgenologic features are stressed. These types are namely Bechterew's disease and spondyloarthrosis deformans.

The author presents another etiologic factor causing somewhat analogous signs which are secondary to ir-

ritative reaction of a pre vertebral abscess due to lodging of a metallic foreign body. This is rather rare, for commonly such a circumstance produces pressure atrophy of vertebral bodies due to transmitted pulsation of the aorta. The main reason that a diagnosis of Bechterew's disease was not made was the restriction of the osseous bridging to the site of the abscess.

WILLIAM R. STECHER, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

Cholecystographic Findings Following Cholecystotomy. E. L. Jenkinson and Joseph M. Foley. Am Jour Roentgenol and Rad Ther, September 1936, 36, 301-304.

Cholecystostomy does not necessarily leave a pathologic gall bladder behind as previous authors concluded for of 25 patients who had had their gall bladders surgically drained from eight months to many years before, 19 or 68 per cent, showed a normal functioning with the dye (Keaphen B) examination.

S. M. ATKINS, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Duodenal Diverticula. Walther Thaler München med Wehnschr, Dec 11 1936 50, 2055-2058.

Duodenal diverticula may be symptomless or present symptoms if marked stasis of food occurs with ensuing diverticulitis, hemorrhage, abscess formation, gangrene and perforation. The lack of muscularis and peristalsis in the diverticulum predisposes to retention particularly in the presence of a narrow neck. The presence of a diverticulitis by direct extension is productive of gastritis, duodenitis, pancreatitis and cholangitis, cholecystitis and hepatitis. In addition, pressure symptoms on neighboring organs by a filled diverticulum may be the only symptoms. The incidence as shown roentgenologically is from 1.2 to 1.7 per cent but anatomically 3 to 13 per cent is found. In the author's series of 1100 gastro intestinal examinations 1.5 per cent showed duodenal diverticula. The most common site is the descending portion of the duodenum particularly in the vicinity of the papilla of Vater and almost always in the concavity of the duodenal loop. The size varied from that of a lentil to a small apple and oddly in this series a predominance of females presented diverticula with occasional double diverticula. Clinical symptoms are vague but summed up as follows: (1) Symptoms are improved in certain postures and by massage, (2) symptom of dullness are almost constant and of long standing, (3) gaseous gastric eructations, nausea, loss of appetite, flatulence, constipation and loss of weight are common findings. However in any non-typical gastric disturbance a roentgenologic examination is indicated and these are readily noted if a careful examination in horizontal and vertical positions with exposures in many planes are obtained. Roentgenologic criteria are briefly: (1) A well-defined density with

mal just after the height of the pulmonary infiltration, but the author emphasizes the fact that this is not a simple post infectious eosinophilia. There is no analogy between the size of infiltrate and degree of associated eosinophilia.

The symptom-complex can be summated as (1) Roentgen pulmonic shadow which is fugacious with a concomitant eosinophilia (2) extremely slight or no definable subjective symptoms, (3) occasionally slight elevation in temperature, and uncommonly an irritative cough.

Ascaride larvæ were never found in the sputum for this was strongly suspected in presence of marked eosinophilia. The lesion could be confused roentgenologically with the terminal pneumonic stage just before resolution but rarely is there such an associated eosinophilia in this affection.

General types of pulmonic infiltration can be classified as (1) Large irregular shadows unilateral or bilateral (2) round focus type resembling the Assmann early pulmonary tuberculosis type, (3) multiple pluricentric unilateral or bilateral infiltrate (4) infiltration sharply demarcated to one pulmonic lobe (5) type resembling secondary infiltration of pulmonary tuberculosis and only distinguished by eosinophilia.

In most cases careful examination reveals a fine pleuritic friction rub, and roentgenologically thickened pleura may be localized particularly to the interlobar fissure. There is a definite seasonal frequency to the syndrome namely maximum in July and August. Two-thirds of the cases were in males. The main etiologic considerations were helminthic infestations and an anaphylactic process. The former has many advocates for it is known that the *Ascaride* larvæ temporarily sojourn in the lung structure. The opinion that the phenomenon is a reaction to a pollen is not met with favor by the author. Other possibilities entertained are bronchial asthma and partial pulmonic atelectasis. Of greatest importance is the differential diagnosis of tuberculosis but rarely does tuberculosis produce such a degree of eosinophilia though occasional findings of from 4 to 7 per cent have been recorded. Another differential factor is the absence of termination into necrosis or evidence of fibrotic replacement in this symptom-complex.

The tuberculin reaction was negative in one third of the cases in spite of the fact that no children were in the group tested. If tuberculosis is considered as the etiology then it is of a hitherto unknown benign form. The author regularly re-examines the chest over a long period of time to eliminate a possible recrudescence and exhibition of tuberculosis. The present conception of this symptom complex is that it is a microbe of the lung but possibly could be a tuberculide.

WILLIAM R. STECHER, M.D.

Artificial Pneumonia and its Treatment. C. Fried. *Strahlentherapie* 1937, 58, 430.

The beneficial effect of roentgen rays in the treatment of inflammatory disease is well known. This includes

also diseases of the respiratory tract. Some investigators have reported good results in the treatment of pneumonia and this induced the author to study the mechanism of the effect experimentally. Six guinea-pigs were injected in the trachea with from 0.3 to 0.5 c.c. of *Staphylococcus aureus hemolyticus* suspension. Three animals were irradiated and three served as controls. Treatment consisted of from 90 to 95 r (in air) applied once (160 kv, 0.5 mm Cu + 1 mm Al 30 cm F.S.D.). A total of 60 animals were treated in this manner and killed at varying intervals. The macroscopic and microscopic examinations of the irradiated lungs showed that there was less infiltration, less hyperemia, less edema, congestion and exudate than in the untreated controls. From the microscopic studies it appeared that following early irradiation the inflammatory process does not fully develop, if irradiation is done later for instance after 24 hours, the fully developed pneumonia takes a less severe course.

ERNST A. POHLE, M.D., Ph.D.

The Roentgenologic Picture of Gangrenous Suppurative Lesions of the Lung. Giuseppe Pilotti. *Arch. di Radiol.* 1936, 12, Nos. 3-4, 153-176.

Pilotti illustrates some selected cases of pulmonary gangrene, points out the characteristics of the suppurative process and emphasizes the value of x-ray examination may have not only in establishing a diagnosis but also in furnishing valuable indications for treatment. The differential diagnosis of the various types of supuration is discussed in detail.

E. T. LEDDY, M.D.

Congenital Lung Cyst. J. Cash King and L. C. Harris. *Jour. Am. Med. Assn.*, Jan. 23, 1937, 108, 274-279.

Congenital cyst of the lung may be defined as an intrapulmonary fluid sac of which the wall is composed of bronchial tissue and the fluid content is a product of the bronchial epithelium. Its formation is attributed to an anomalous occlusion of the bronchus in the embryo. In the last decade 152 cases have been described. The growth may be masked by secondary complications such as abscess or rupture and may be overlooked by the pathologist unless the bronchi are carefully searched for the site of obstruction. Those cases not diagnosed clinically which undergo spontaneous recovery never come to autopsy. Therefore the number of cases found at autopsy gives an inaccurate conception of its true incidence. The condition is now being recognized with increasing frequency with present day improved methods of roentgenologic technique.

It is almost unanimously agreed that cystic disease is congenital in origin. In 1928 Mueller published an excellent article giving a critical review of theories advanced prior to that time to which the reader is referred.

All fluid cysts of the lung are caused by Jackson's so-called stop valve occlusion. When the wall of the cyst is sufficiently strong to support an intracystic pressure

INFLAMMATORY DISEASES

The Method of Irradiation with Small Doses W Wieser Strahlentherapie 1937, 58, 646

The author briefly discusses the principles of radiation therapy in inflammatory disease. In acute cases the doses varied between 15 and 100 r effective in the diseased tissue chronic inflammations receive from 1 to 100 r per sitting. Some examples are given to illustrate the necessity of individualization and the danger of cumulative effect in cases of prolonged treatment.

ERNST A. POULE, M.D., Ph.D.

THE KIDNEYS

Congenital Polycystic Disease of the Kidneys Hugh R. Spencer Southern Med Jour., May, 1937 30, 524-527

The author summarizes polycystic disease of the kidneys as follows. It is a congenital affection characterized by the formation of multiple cysts in both kidneys and in the liver in 30 per cent of the cases.

The incidence is about 1:3523 hospital admissions and 1 in every 500 autopsies. There is no difference in sex incidence. The disease is seen in the newborn and in adults in or past the third decade.

The disease results from embryologic maldevelopment. Symptoms are directly or indirectly the result of a progressive pressure atrophy of renal parenchyma or of infection.

The important clinical findings are mass, urinary changes characteristic of renal failure, decreased phthalin output, a well tolerated non protein nitrogen retention, intermittent hematuria and hypertension.

The characteristic findings on pyelography are:

- (a) Elongation of the pelvis and major calices with blunting of the minor calices
- (b) Right angulation of the ureter in its relation to the pelvis
- (c) Displacement of the ureter toward the midline
- (d) Bilateral pelvic changes

DAVIS H. PARDOLL, M.D.

KYMOGRAPHY

Roentgen Kymographic Observations on the Behavior of the Heart in Hot Baths Joseph Ritter München med Wehnschr., Feb. 26 1937 84, 339-341

The author considers that, although the action of hot baths on the circulatory system is little understood and although their use is on an empirical basis, they have a certain place in stages of decompensated heart disease. He sought to study the heart changes in hot baths with a roentgen kymograph of the multiple slit type arranged over the tub so that the patient need not be moved. After mention of the methods of previous observers and their errors it is pointed out that the method (of size observation) has intrinsic errors and

that tendencies to enlargement may be within the limits of experimental error. For this reason functional observations are important. The author's observations show that a hot bath can produce an extraordinary increase in heart action, as measured by stroke volume; in addition, there is increased filling and pulsation of the great veins, an increase of the vascular lung markings and decreased apical beat. He also believes this method of study opens the way to a better understanding of the various factors, such as temperature of the bath, water pressure, effervescence, and so on.

L. G. JACOBS, M.D.

Roentgenologic Demonstration of Swallowing Function Disability Max Dahm München med Wehnschr., Dec. 11 1936, 83, 2050-2051

An interesting demonstration of how kymography enables one to delineate minimal degrees of swallowing dysfunction, employing a barium meal is discussed. Ordinary technique in many instances would not disclose the disordered function, particularly the type of paralytic origin, viz. multiple sclerosis, bulbar paralysis, pseudo bulbar paralysis, post encephalitis. A detailed account of the various actions of the component parts in swallowing together with altered activity in paralysis is given.

WILLIAM R. STECHER, M.D.

THE LUNGS

Fleeting Pulmonary Infiltration with Eosinophilia W. Löffler Schweiz med Wehnschr. Nov. 7 1936 45, 1069-1076

Fifty-one observed cases showing this benign syndrome are reviewed, portraying the discrepancy between the alarming objective signs and benignity of the course of the syndrome. The roentgenograms show patchy soft appearing infiltration which superficially strongly resembles an advanced pneumonitis. Surprisingly in a few days there is disappearance of the pulmonary signs and concomitant absence of eosinophilia which is quite marked in the case of pulmonary infiltration. Roentgenographically, the characteristics of this entity are the inordinately rapid localization and disappearance of the pulmonary infiltration, which varies from flaky to cloudy structure either demarcated or fading out in the periphery and single or multiple or unilateral or bilateral. The entire metamorphosis occurs in from three to eight days. This fact shows the importance of serial roentgenographic re-check for the greatest confusion lies in mistaking this for a tuberculous process.

The eosinophilia may reach 66 per cent with a leukocytosis of 14,000 and an absolute count of 9,000 is not unusual as contrasted to a norm of 320. The eosinophilia is always present in this entity and usually maxi-

pyogenes and pneumococcus organisms are also frequent causative agents

The first skeletal manifestation of the disease is constantly localized in a single metaphysis of one of the long bones of the extremities or in the juxta-epiphyseal region of other bones of the growing skeleton. The primary bone involvement is not in the medullary cavity or cortex of the main shaft of a growing bone. During the early acute stage of the disease the infection is limited to a single metaphysis. However, subsequent to direct or hematogenous spread of the infection and in the subacute or chronic phases of the disease the main shaft, the neighboring joint, and the medullary cavity may be affected. If the infection is not in the main shaft and medullary cavity during the acute stage there is no reason for their surgical exposure. The surgical attack should be limited to the site of infection or metaphysis.

The name 'metaphysis' was first used by Kocher to describe the broad cancellous end of the diaphysis which is adjacent to the epiphyseal disk. The metaphysis represents the bone most recently developed from the epiphyseal cartilage or disk and is, therefore, more vascular, more delicate, more susceptible, and less immune than the older bone of the shaft, which is dense and compact. The marrow of the shaft which occupies the medullary cavity is bountifully provided with cellular elements, while the marrow of the metaphysis, which fills the interstices between the trabeculae of the cancellous bone, presents a paucity of phagocyte cells.

The cortex of the middle of the shaft is either more or slightly less than one-fourth inch (0.64 cm) in thickness while the cortex surrounding the metaphysis is much thinner and near the epiphyseal disk it is paper thin. This explains the ease with which infection within the cancellous metaphysis may perforate into the subperiosteal space and why the rupture is usually juxta epiphyseal.

The metaphysis is richly supplied by the terminal branches of the nutrient artery. The vascularity of the juxta epiphyseal region is abundant and consists of a bed of terminal capillary loops where the blood current is slowed and where infection is very likely to settle as a bacillary embolism.

The epiphyseal circulation is separated from the vascular system of the metaphysis by a practically avascular barrier, the epiphyseal disk.

The problem of joint involvement secondary to acute hematogenous osteomyelitis depends largely on the anatomic relationship between the joint capsule, the periosteum, the metaphysis, and the epiphyseal disk. Certain metaphyses are intracapsular (hip) while others are either entirely extracapsular (ankle) or intracapsular and extracapsular (shoulder). When a metaphysis is intracapsular the periosteum no longer protects the joint from involvement since the greater portion of the periosteum is attached to and blends with the capsule instead of with the epiphyseal disk. Perforation of the intracapsular metaphyseal cortex and its thin periosteal covering permits the infection to in-

vade the joint cavity directly. The metaphysis of the proximal end of the femur is completely intracapsular, infection of the hip joint is therefore, the rule in acute hematogenous osteomyelitis of the proximal end of the femur. Perforation of the distal tibial metaphyseal cortex does not invade the ankle joint directly, since this metaphysis is entirely extracapsular. Clinical experience teaches that infection of the knee joint is an infrequent complication of acute hematogenous osteomyelitis of either the distal end of the femur or the proximal end of the tibia.

Surgical drainage of acute hematogenous osteomyelitis without joint infection should always be made through an extracapsular dissection.

CHARLES G. SUTHERLAND, M.B. (Tor.)

THE OVARIES

Contribution to the Irradiation of the Ovary. G. H. Schneider. *Strahlentherapie*, 1937, 58, 238.

The author publishes a series of tables giving the doses required for temporary and permanent sterilization by roentgen rays, also for the treatment of uterine fibroids and cases with ovarian dysfunction. As an example it may be mentioned that he recommends for permanent sterilization in women from 20 to 25 years of age dosage of from 323 to 467 r, and for the age group from 46 to 50 years dosage of from 253 to 363 r effective in the ovary.

ERNST A. POHLE, M.D., Ph.D.

PEPTIC ULCER

The Frequency of Air under the Diaphragm in Perforated Gastric and Duodenal Ulcer. Sydney E. Johnson. *Jour. Am. Med. Assn.* Jan. 23, 1937, 108, 295-296.

Demonstration of spontaneous pneumoperitoneum is pathognomonic of perforation. The value of the sign depends on the percentage of cases in which the sign can be elicited. The charts of all patients admitted over a five year period with an admission diagnosis of perforated peptic ulcer, were studied. There were 76 cases of which 30 had no x-ray examination. Thirty-five of the remaining 46 gave the positive finding of air under the diaphragm and 11 were negative.

Of the 11 negative cases one was eliminated because it was found at operation that the ulcer had not perforated. Three others were excluded because there was no operative or necropsy confirmation of the clinical diagnosis. The remaining seven patients in the negative (x-ray) group were proved by operation to have perforated ulcers.

All of the 35 patients in the positive group were proved by operation to have perforated ulcers.

The time between the attacks and the roentgen examination in the 35 patients who showed air under the diaphragm ranged from one to 36 hours and averaged eight and one half hours.

CHARLES G. SUTHERLAND, M.B. (Tor.)

which inhibits the secretory activity of the mucous cells of the germinal lining membrane the fluid cyst remains as an asymptomatic parasite. Infection of a cyst may occur by extension of bacteria through its walls, causing isolated abscesses. If the cyst ruptures into the pleural cavity a hydrothorax results, or if infected a pyothorax results. If pneumatized tissue is encountered in rupture air will be present above the fluid line.

Any classification which goes beyond the division of congenital and acquired constitutes merely an enumeration of the different pathologic states that may develop in the progress of the growth.

Unfortunately, there is no symptom or train of symptoms pathognomonic of lung cysts. Many cases without secondary infection are symptom free and may not be recognized at all.

In their review of the literature, the authors found only one instance in which a clinical diagnosis of an complicated lung cyst was made prior to roentgenologic examination.

An analysis of the reported cases indicated a high mortality rate in infants and children. Fluid cysts do not of themselves carry a grave outlook, but the development of infection and the establishment of bronchial communication are fatal complications.

CHARLES G. SUTHERLAND, M.B. (Tor)

Röntgen Therapy in Primary Carcinoma of the Lung during 1928-1936. L. Popovic. *Strahlentherapie*, 1937, 58, 543.

The paper consists mostly of a tabulated analysis of the cases of carcinoma of the lung observed by the author. They are grouped according to the type of treatment given. Five patients received incomplete therapy, nine were treated according to the fractional method, 48 with the saturation method, and eight with the Coutard method. A small percentage of the patients were temporarily improved.

ERNST A. POHL, M.D., Ph.D.

The Role of Atelectasis in Post-operative Pulmonary Complications. Editorial. *Jour. Am. Med. Assn.* March 13, 1937, 108, 837, 888.

Post-operative pulmonary complications occur in from 2 to 4 per cent of all operative interventions. When operations on the upper abdominal region alone are considered, this figure rises to 10 per cent and higher. The mortality from the same cause is given as 0.6 or one in every 200 cases. Studies revealed that the introduction of local and spinal anesthesia did not diminish either the morbidity or the mortality from this cause.

Research on the pathogenesis of the post-operative pulmonary complications resulted in three distinct theories: that of aspiration pneumonitis; that of infected emboli; and more recently, that of pulmonary atelectasis.

Since William Pasteur, in 1910, revived interest in post-operative collapse of the lung, the number of reported cases has risen so that Coryllos believed its incidence to be nearer 50 or 75 per cent.

The most striking clinical and roentgenologic sign of massive collapse of the lung is the unusually high position and immobility of the diaphragm. A reduction of the vital capacity to 30 and 50 per cent of the normal in patients following an abdominal operation has been demonstrated. There is a direct relationship between the reduction in the vital capacity and the incidence of pulmonary complications.

The second factor is the accumulation of mucus in one or another bronchus. The air in the occluded lung or lobe is absorbed and collapse of the alveoli follows.

The two important factors in determining the collapse are the viscid and tenacious mucus in the bronchial tree and the impairment of the natural means of defense, namely coughing, respiratory movements, and ciliary action.

The more or less temporary occlusion of a bronchus leads to the absorption of the alveolar gases of the collapsed lung. The further course of the atelectasis will depend on the duration of the obstruction and the virulence of micro-organisms contained in the mucous exudate causing the obstruction. The presence of virulent pneumococci will cause pneumonia; the presence of pyogenic organisms may lead to suppuration, and the presence of certain fusiform anaerobes to gangrene of the lung. Thus atelectasis, either patchy involving small areas, or massive, is the forerunner of post-operative pneumonia or bronchopneumonia.

CHARLES G. SUTHERLAND, M.B. (Tor)

LYMPHOGRANULOMA

Total Teleroentgen Therapy. F. Sluys. *Strahlen therapie*, 1937, 58, 599.

For total body exposure to roentgen rays the author uses distances of from 2 to 2.5 meters and a filter of 0.5 mm Cu + 2 mm Al. The doses applied should not exceed 50 r, since for instance in Hodgkin's disease, even 15 r are poorly tolerated. The results were good in lymphatic and myelogenous leukemia; occasionally a patient with Vaquez disease responded. A few cases with Hodgkin's disease were benefited, although no definite rules can be established as to the use of general body exposure in lymphogranulomatosis.

ERNST A. POHL, M.D., Ph.D.

OSTEOMYELITIS

Acute Hematogenous Osteomyelitis in Children. Vernon L. Hart. *Jour. Am. Med. Assn.* Feb. 13, 1937, 108, 524-528.

Acute hematogenous osteomyelitis is a local manifestation of a blood stream infection which is usually transient. The skeletal infection is always secondary to a remote infection, the source of which is usually the integument or the mucous membranes of the upper respiratory organs. A bacteremia necessarily precedes the localization of infection in the osseous system. Cultures of blood and pus demonstrate that the most common infective agent is *Staphylococcus aureus*, *Staphylococcus albus*, *Streptococcus albus*, *Streptococcus*

The authors take up particularly the type in which a mild or atypical Reynaud's disease exists at or some time before the onset of the skin changes. They point out that locally there is a decreased vascularity of the skin with an increase in the tonicity of the arterioles and a diminished circulation. In addition, there is frequently an hyperparathyroidism with hypercalcemia and decalcification of the osseous framework.

Roentgenographic examination will occasionally show diffuse calcification which is not limited to the spongiosa but also involves the cortex. It is more pronounced in the extremities and is frequently localized in the hands and feet especially the phalanges. Some cases were observed in which decalcification was so intense that the osseous structure of one or more phalanges was not distinguishable on the roentgenograms.

Treatment is concerned with perivascular sympathectomy to decrease the vasospasm or parathyroidectomy (or ligation of the inferior parathyroid arteries) to correct the endocrine dyscrasia. In cases with bilateral involvement both procedures were used. Results were satisfactory in most of the cases. The authors prefer the removal of the parathyroids.

JOHN E. WHITELEATHER, M.D.

THE SHOULDER JOINT

Backward Dislocation of the Shoulder. H. Wijnblad. *Nord med tidskr*, Oct 10, 1936, p 1679. (Reprinted by permission from *British Med Jour*, Dec 12 1936, p 98 of *Epitome of Current Medical Literature*.)

The author has observed as many as seven cases of backward dislocation of the shoulder in a Swedish hospital between 1931 and 1935 and it seems that this dislocation is not as rare as the scanty space devoted to it in the textbooks would suggest. Of the two forms of this dislocation the subacromial and the infraspinous the former would seem to be the more common. The clinical picture of this dislocation was in all the author's cases characteristic but its diagnosis was by no means easy in the muscular or fat cases. In the first case the correct diagnosis was not made before it was established by a radiological examination and in a later case both the clinical and the radiological examinations were at first at fault although the patient a woman was thin. The correct diagnosis was made next day when the radiological examination was repeated. In all seven cases reposition with or without anesthesia was easily effected simply by pulling on the arm in its long axis and exerting direct pressure on the head of the humerus from behind or by direct pressure alone. But recurrence of the dislocation took place as easily as the reposition in two cases and in one of these the shoulder had been put out of joint in the same way three times during the past two years. The duration of treatment ranged as widely as from one to twelve months and in three cases troubles persisted in the form of pain at work and at night, loss of strength, and limitation of movement notably that connected with abduction and outward and inward rotation.

THE SPINE

Anomalies and Fractures of the Vertebral Articular Processes. Wilbur Bailey. *Jour Am Med Assn*, Jan 23 1937, 108, 266-270.

Fissures across the vertebral articular processes may be formed by the presence of an ununited accessory center of ossification opposite the tips of the articular processes or they may be the result of fracture of the articular processes. The differentiation between these can nearly always be made if proper value is given to the history of the injury and to the appearance in the roentgenograms.

Fissures due to anomalies are usually transverse, well demarcated and often bilateral or multiple.

Fractures of the articular processes in combination with severe injuries of the spine in which there is an actual dislocation of one vertebral body on another are not at all unusual. One or more articular processes are frequently sheared off under such circumstances. Isolated fractures in which the vertebral bodies alone are involved however constitute a rarity.

CHARLES G. SUTHERLAND, M.B. (Tor.)

THE STOMACH

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S. M. ATKINS, M.D.

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The technical phase of the study of the stomach has been greatly advanced by the innovation of the recent procedures of mucous membrane relief pattern studies, cinematography of peristaltic waves, multiple superimposed projections and the recently advocated kymographic method. In addition the great advance in speed and sharpness of detail by the newer apparatus has greatly enhanced the detection of filling defects and disturbance in function and morphology of the stomach. Nonetheless the important factors of cognizance of what is occurring in neighboring organs are not discernible, viz. presence of metastasis in abdominal lymph nodes or early metastatic nodules in liver, etc. The

PNEUMOTHORAX

A Case of Spontaneous Contralateral Pneumothorax and Artificial Pneumothorax Jacques Stephanie Schweiz med Wchenschr, Nov 7, 1936, 45, 1068, 1089

A case of bilateral pulmonary tuberculosis with an artificial pneumothorax, left side, is presented in which there was a sudden spontaneous pneumothorax of the right side

WILLIAM R STECHER M D

RADIATION

Principles of X-ray Treatment O David Schweiz med Wchenschr Feb 6 1937 67, 120 121

The author points out that in spite of the older biologic units and the more recent physical unit the r, that the true therapeutic unit is the tolerance dose. This is known from the works of several authors cited, to vary with the size and time relation of fractionation. He points out that in cases in which therapy is cauterizing little individualization is possible. Special reference is had to cases in which limiting or stimulating vital processes are in question. It is pointed out that in thyrotoxicosis and lymphoblastoma therapy is essentially symptomatic rather than etiologic and that for this reason the least amount that will control the symptoms is indicated. This *per se* rules out iron clad schedules. Cumulative effects must be kept in mind. The author concludes with two axioms—that ill guided therapy for the sick is worse than none and that we ought forever to discard schematic therapy and keep to individualization though more inconvenient and difficult.

L G JACOBS M D

Principles of Radiation Therapy of Blastomatous and Hyperplastic Disease The Single Massive Dose Method H Wintz Strahlentherapie 1937, 58, 521

The author has always advocated the application of the entire dose in as short a time as possible in roentgen therapy of malignant disease. In his clinic one series takes from four to five hours for carcinoma of the uterus; this is followed eight or nine weeks later by irradiation of the parametria. The patient usually is confined to the clinic for a period of only five or six days. Although this type of treatment requires most accurate dosage measurements it is, in the author's opinion, most efficient in destroying the malignant growth. Some other advantages are that the total dose administered to the pelvis is relatively small as compared with the Coutard method, the difference in radiosensitivity between normal and diseased tissue is taken full advantage of; the skin is in good condition after the treatment and no irreparable changes in the connective tissue within the pelvis have been observed. The economic factor is also in favor of this method and the end results in carcinoma of the uterus and of the breast have been excellent according to his statistics.

ERNST A POHLE, M D Ph D

RADIUM

Experimental Radium Poisoning II—Changes in the Teeth of Rabbits Produced by Oral Administration of Radium Sulphate Maurice Rosenthal Am Jour Med Sci, April, 1937, 193, 495-501

The changes in the teeth of four rabbits were studied following the administration of 100 micrograms of radium sulphate. The teeth were studied at various intervals of time by photographic, autographic and histologic methods.

Rosenthal found that the radium not only was stored in the alveolar bone but also in the teeth, producing definite changes in the morphologic picture of the tooth. The findings, as summarized by the author, showed that 'there is a marked disturbance in calcification with resorption of teeth and the formation of ankylosis by the ingrowth of newly formed bone which also replaces the absorbed bone of the alveolar process. The essential changes in the enamel organ consist of flattening and atrophy of the ameloblasts with hyperplasia of the stratum intermedium and subsequent degeneration and necrosis of the entire formative structure. The normal pulp tissue is replaced by abnormal, irregular secondary dentine masses. The surrounding periodontium shows an extreme hyperplasia of fibroblastic tissue with invasion of surrounding structures. The development of cysts arising from epithelial rests in this membrane is also an interesting finding.'

G E BURCH M D

Radium Treatment with Small Intensities K Waserburger Strahlentherapie 1937, 58, 668

The author has treated a number of lesions with radium applicators delivering small intensities. In thyrotoxicosis he uses from 40 to 50 mg of radium filtered through 0.5 mm Pt. This is left in place at 2 cm distance for approximately 60 hours over a period of from 8 to 10 days. This corresponds to approximately 0.4 r/min. Eleven out of 14 patients became symptom free. A similar technique was used in the treatment of plastic induration of the penis in hemangioma, and in circulatory disturbances in the extremities. In some hemangiomas from 4 to 8 radium needles containing 2 mg radium and filtered through 0.5 mm Pt are inserted to apply about 40 per cent of the dose customary for a carcinoma of the same size.

ERNST A POHLE M D Ph D

SCLERODERMA

The Surgical Treatment of Scleroderma Rene Le-nche, Adolphe Jung and Michael de Bakey Surgery January 1937, 1, 6-24

Scleroderma is a term applied to the syndrome characterized by sclerosis, induration and pigmentation of the skin which may be localized or generalized and frequently associated with asthma, digestive disturbances, arthritis, muscle atrophy, and other symptoms depending on the gravity and degree of involvement.

The authors take up particularly the type in which a mild or atypical Reynaud's disease exists at or some time before the onset of the skin changes. They point out that locally there is a decreased vascularity of the skin with an increase in the tonicity of the arterioles and a diminished circulation. In addition there is frequently an hyperparathyroidism with hypercalcemia and decalcification of the osseous framework.

Roentgenographic examination will occasionally show diffuse calcification which is not limited to the spongiosa but also involves the cortex. It is more pronounced in the extremities and is frequently localized in the hands and feet, especially the phalanges. Some cases were observed in which decalcification was so intense that the osseous structure of one or more phalanges was not distinguishable on the roentgenograms.

Treatment is concerned with perivascular sympathectomy to decrease the vasospasm or parathyroidectomy (or ligation of the inferior parathyroid arteries) to correct the endocrine dyscrasia. In cases with bilateral involvement both procedures were used. Results were satisfactory in most of the cases. The authors prefer the removal of the parathyroids.

JOHN E. WHITELEATHER M.D.

THE SHOULDER JOINT

Backward Dislocation of the Shoulder. H. Wijnblad. *Nord med tidskr*, Oct 10, 1936, p 1679. (Reprinted by permission from *British Med Jour*, Dec 12 1936, p 98 of *Epitome of Current Medical Literature*.)

The author has observed as many as seven cases of backward dislocation of the shoulder in a Swedish hospital between 1931 and 1935 and it seems that this dislocation is not as rare as the scanty space devoted to it in the textbooks would suggest. Of the two forms of this dislocation the subacromial and the infraspinous the former would seem to be the more common. The clinical picture of this dislocation was in all the author's cases characteristic but its diagnosis was by no means easy in the muscular or fat cases. In the first case the correct diagnosis was not made before it was established by a radiological examination and in a later case both the clinical and the radiological examinations were at first at fault although the patient a woman was thin. The correct diagnosis was made next day when the radiological examination was repeated. In all seven cases reposition with or without anesthesia was easily effected simply by pulling on the arm in its long axis and exerting direct pressure on the head of the humerus from behind or by direct pressure alone. But recurrence of the dislocation took place as easily as the reposition in two cases and in one of these the shoulder had been put out of joint in the same way three times during the past two years. The duration of treatment ranged as widely as from one to twelve months and in three cases troubles persisted in the form of pain at work and at night loss of strength and limitation of movement notably that connected with abduction and outward and inward rotation.

THE SPINE

Anomalies and Fractures of the Vertebral Articular Processes. Wilbur Bailey. *Jour Am Med Assn* Jan 23 1937, 108, 266-270.

Fissures across the vertebral articular processes may be formed by the presence of an ununited accessory center of ossification opposite the tips of the articular processes or they may be the result of fracture of the articular processes. The differentiation between these can nearly always be made if proper value is given to the history of the injury and to the appearance in the roentgenograms.

Fissures due to anomalies are usually transverse, well demarcated and often bilateral or multiple.

Fractures of the articular processes in combination with severe injuries of the spine in which there is an actual dislocation of one vertebral body on another are not at all unusual. One or more articular processes are frequently sheared off under such circumstances. Isolated fractures in which the vertebral bodies alone are involved, however constitute a rarity.

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author wishes to take inventory of our current expensive methods of diagnosis in gastric carcinoma.

It is a *sine qua non* that any hope of cure in gastric malignancy is entirely dependent upon early arrival at diagnosis, for in the light of present knowledge surgical procedures should be effective. It is patent that in the vast majority of cases the patient will present himself for examination only when symptoms are present which factor will in the majority of instances permit of diagnosis of a great percentage of far advanced malignancies. In contradistinction there are many subjects who having symptoms referable to the gastric tract present themselves to the radiologist with unquestioning confidence that the examination will be conclusive in either demonstrating or eliminating a possible lesion. This immediately places the radiologist in the position of arbiter in the court of last appeal and naturally the question arises: Is this justifiable? Can one attain such exactitude as is awaited by the referring physician? Berg is quoted as stating that in the face of negative findings roentgenologically one cannot be absolutely certain that malignancy is not present for his experience proved that a small malignancy with wide spread metastasis can be present, without altering the functional and morphologic outline of the stomach and even the mucous membrane relief was not altered. In addition roentgenologically undiagnosable is malignancy infiltrating diffusely sub mucously, with no fibrotic reaction.

The next issue is the question of diagnosis of malignancy without symptomatology, which diagnosis is the only tenable hope for cure. Finding of coincident beginning carcinoma of the stomach is not rare in autopsies with cause of death entirely unrelated. The number of such fortunate diagnoses roentgenologically is ridiculously small suggesting that it has been overlooked in many instances. It is obvious that all malignancies commence cellularly and originally are microscopic in size which fact precludes the diagnosis in this stage by any known methods. The question then resolves itself: Is an anatomico microscopic discernible carcinoma which has caused changes in the gastric lining always demonstrable roentgenologically? Inasmuch as there is no anatomic negative roentgenographic control, this question can be answered only by the experience of practice.

The common practice of reporting "negative" is strongly deprecated for such an unqualified negation can be made only in the light of innumerable exposures obtained in numerous projections etc. To wit, the rather high incidence of failing to diagnose a carcinoma of the cardia which should be readily discerned by the deflection of the esophageal stream at the esophageo-cardiac juncture. In the author's experience not one case of thoroughly studied gastric series which eventually went to operation or autopsy, showed the presence of malignancy with the roentgen findings reported as negative. In many cases in which the primary tumor was not readily found but attributed to the stomach on account of the site of metastatic involvement, etc. the primary neoplasms were finally dis-

covered in the gall bladder, biliary passages, pancreas, duodenum, and colon. The author emphatically states that it is not the method of examination i.e., whether the compression technique or other refinement is employed but the examiner who is at fault when an erroneous diagnosis is made. He also warns not to excuse one's shortcomings by blaming the non-cooperation of the patient.

It is possible that the earliest diagnostic criteria will be those obtained by the kymographic method, showing dysfunction of peristalsis, but to date this has certainly not justified its claims. One must also consider the fact that an original "negative" gastric examination carries no weight later, for a carcinoma might evolve at a later date which was not present at the time of original examination. Nonetheless one can state with a great degree of security that a properly conducted negative gastric x-ray examination is of great weight.

Further difficulties in the presence of aberrations in the normal function and contour of the stomach present themselves in the differentiation of carcinoma from other entities, such as ulcer, syphilis, tuberculosis, amyloidosis, lymphogranuloma etc. Of greatest practical importance is the differential diagnosis of benign ulcer and gastric malignancy. Though the main sign is the niche rarely a carcinoma presents a similar finding, and in fact there may be malignant change in an ulcer. Haudek's description of ulcer niche and carcinoma crater is very reliable. Occasionally the differentiation is impossible even with laboratory findings and clinical studies, and most strangely may be confused histopathologically if biopsy or section is not obtained at just the correct site. The most common site for malignant change in an ulcer is in the prepyloric region near the angularis never adjacent to the duodenum, and rarely in the ascending portion of the stomach. It behooves one therefore to consider any long standing ulcer in the prepyloric region as potentially malignant—or rather as undergoing malignant change—and to recommend operation. Only in this manner will the lesion be detected early.

Polyps, particularly solitary may confuse one with early malignancy but in general can be diagnosed radiographically. Again, the warning of the strong probability of malignant change in polyps makes it mandatory to have operative intervention for confirmation and removal.

The distinguishing signs between linitis plastica and circular antral carcinoma are not always absolute, and operative measures should be instituted when in doubt. In pyloric stenosis it is almost impossible to distinguish benignancy from malignancy and again operation should be mandated.

Rare diseases such as syphilis, tuberculosis, amyloidosis, deformity due to adhesions and extra gastric tumors are sometimes difficult to diagnose. Gastric spasm particularly of the pylorus may not infrequently suggest an organic stricture, particularly in hypertrophic pyloric sphincter entity. The mucous

membrane pattern is of great help in distinguishing an infiltrating lesion from the above.

At times, marked hyperplastic gastritis will superficially resemble carcinomatous filling defect while additional suggestion of anemia, hematemesis and loss of weight, with palpable resistance, add further difficulties. It is not uncommon to find localized hyperplasia in the antral region, and polyps are prone to develop therein. The opinion has been expressed that this latter entity should be considered as pre-cancerous and surgically removed.

Difficult simulants to distinguish are isolated lymphogranulomatous lesion of the stomach, leukemic and pseudo leukemic infiltration of the stomach. In all questionable cases a therapeutic test of irradiation followed by shortly spaced intervals with re-examination will suggest a radiosensitive lymphoblastoma, if present. From a purely anatomical consideration, the lesions are radiographically indistinguishable from one another. A differential point between actinomycosis and carcinoma of the stomach is the predilection for the greater curvature in the former but this is an unreliable criterion. Gastric sarcoma is rare and the site of predilection is along the greater curvature aspect near the fundus, often assuming a ball shape and indenting the diaphragmatic cupola.

One should not get the impression that gastric carcinoma is a difficult and treacherous roentgenologic diagnosis, but merely that, though in most cases characteristic signs are present, in a very small percentage of cases the findings will be deceptive and limited further by the natural pale of radiologic acumen.

WILLIAM R. STECHER, M.D.

Leukemia of the Stomach Producing Hypertrophy of the Gastric Mucosa Leo G. Rigler. *Jour Am Med Assn*. Dec 19, 1936, 107, 2025-2028.

Generalized leukemic infiltration of the viscera, as well as of the bones, is not uncommon. Involvement of the gastro-intestinal tract is repeatedly observed at autopsy. The changes produced by this disease in the stomach and in the upper part of the duodenum present a bizarre picture in the roentgenogram. There are few cases recorded in which the diagnosis was successfully made by means of roentgen examination. Two types of abnormality may be observed on roentgen examination, first a localized infiltration, often near the pylorus with a marked constriction of the lumen of the stomach and second a remarkable enlargement of the folds of mucous membrane of the stomach. Similar changes were found in the duodenum in both types of cases. The roentgen changes in the second type were interpreted as being due to an extreme grade of hypertrophic gastritis or an unusual form of multiple polyposis.

In many instances of leukemic infiltration of the gastro-intestinal tract the blood picture may be normal. This makes the diagnosis difficult.

The author reports a case in which the roentgen examination suggested this lesion in a patient formerly treated for cervical and buccal adenopathy. He made

a temporary recovery under radiotherapy and died one year later. Autopsy could not be obtained. A second patient showed no response to treatment and was still living at the end of eighteen months.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Chronic Gastritis R. Schindler, M. Ortmayer, and J. F. Renshaw. *Jour Am Med Assn*, Feb 6, 1937, 108, 465-468.

The diagnosis of chronic, non specific gastritis has been obsolete for 30 years. Recent histologic and gastroscopic research have shown that chronic inflammation of the stomach is very common.

In the examination of a large group of patients with abdominal complaints 23 per cent were found to have normal stomachs as judged by gastroscopic examination of healthy persons of all ages. About 50 per cent of the group presented mucosal changes similar to those of chronic inflammation of other mucous membranes either layers of whitish, grayish, or greenish mucus or hyperemic spots. These lesions usually healed and the gastroscopic picture of these was designated "superficial gastritis."

Some of these showed, in later gastroscopic examinations, thin greenish gray spots that did not change in subsequent examinations. These were designated as "atrophic gastritis." This atrophic gastritis was observed without a preceding superficial gastritis, for instance, in cases of pernicious anemia. Total atrophy was also observed.

"Hypertrophic gastritis" they considered a separate clinical entity. Gastroscopically this exhibited a swollen thickened, velvety mucous membrane, often containing hemorrhages and erosions and showing nodules or large nodes, creases, and crevasses. The course of hypertrophic gastritis is typified by failure of the mucosa to revert to normal and sudden recurrences of symptoms even while on careful management. The small erosions always heal within a week but others may appear concurrently. No atrophy develops.

A fourth form of chronic gastritis, that of the post-operative stomach offered the worst prognosis. All three forms of gastritis occur combined.

X-ray relief technic which gives such splendid results in ulcer and cancer diagnosis is disappointing in chronic gastritis.

CHARLES G. SUTHERLAND, M.B. (Tor.)

THE THYROID

Roentgen Therapy of Hyperthyroidism P. Hess. *Strahlentherapie*, 1937, 58, 74.

The author analyzes the results of roentgen therapy in hyperthyroidism in 140 patients observed during the last 10 years. He recommends doses of from 150 to 180 r per sitting. One series consists of six sittings given over a period of from two to three weeks. Two or three series may be applied at intervals of from six to eight weeks. In severe cases the single dose must usually be reduced. The total dose in this type of case should reach from 3 000 to 4 000 r. In evaluating the

results the author classified his patients under thyrotoxicosis Basedow's struma, and true Basedow's disease. The respective percentages of cures in these groups were 40.5, 45, and 50 per cent, giving an average of 47 per cent. Improved were 37 per cent, 16 per cent had no benefit from the irradiation. It is obvious therefore, that in Basedow's disease the results were most striking. There was no mortality in this series of patients while on the other hand many severe cases were improved by radiation therapy.

FRANK A. POHLE, M.D., Ph.D.

TUBERCULOSIS, PULMONARY

Radiography and Tuberculosis Mortality. Franz Freund. *Wien klin Wchnschr*, Sept 4, 1936, 49, 1096-1098. (Reprinted by permission from *British Med Jour*, Dec 12, 1936, p. 97 of *Epitome of Current Medical Literature*.)

The author has been able to confirm the remarkable fact reported by other observers that a radiographic examination may reveal an advanced tuberculous lesion in persons apparently in fair health and not presenting signs of tuberculous lung infection on clinical examination. Early radiographic diagnosis followed by early treatment was responsible for a considerable decrease in the number of cases progressing toward caseation of the tuberculous infiltration.

Dr. Freund's observations are based on the investigation of 20,000 employees of the Vienna Tramways. Up to 1928 the mortality from tubercle among them was roughly the same as for the residential quarters of Vienna inhabited mainly by fairly well-to-do people. The poorer districts showed a higher mortality. But beginning with 1928 the mortality among the tramway employees dropped considerably and reached 0.5 per 1,000 (for men) in 1933, whereas the mortality from tubercle for the better classes of Vienna has not varied appreciably since 1914. The improved statistics among the tramway employees can only be explained by early radiographic examinations available to them since 1928.

Cervical Rib and Tuberculosis. Giloreto d'Agostino. *Archivio di Radiologia* 1936, 12, Nos. 3-4, 177-184.

The author found in a study of 1,110 roentgenograms 18 cases of cervical rib, two-thirds of which were associated with frank pulmonary tuberculosis. He feels

there must be some cause-effect relationship here and offers roentgenographic findings in support of his thesis.

E. T. LEDDY, M.D.

Errors in Diagnosis of Tuberculosis with Particular Reference to Undulant Fever. A. Behrmann. *Munchen med Wchnschr*, Sept 25, 1936, 39, 1591, 1592.

A brief review of the numerous symptomatic complaints of incipient pulmonary tuberculosis are enumerated, and the author stresses the great importance of an early roentgenographic examination in all undetermined complaints which might remotely be caused by a tuberculous infection. An outline of the major and tuberculous pulmonary affections which might produce hemioptysis is presented: viz. chronic bronchitis, bronchiectasis, pneumoconiosis, atelectatic process, chronic pneumonitis, lung abscess, syphilis of the lung, aeoplasms, parasitic infestations, etc. Also this symptom is commonly manifest in cardiac decompensation, and in aneurysm of the aorta, trauma, so-called hemorrhagic diathesis, etc. It is not unusual that lymphogranuloma is considered as tuberculosis for a long period of time, even confused roentgenologically symptomatically and with the fever reaction (Pel-Ebstein type). Chronicity of slight elevation of temperature or subnormality is not unusual in tonsillar disease, sinusitis, middle ear disease, or chronic infections of abdominal organs (appendix) and urinary tract. Of particular note is the confusion in diagnosis in the presence of a paratyphoid infection. Recently there has been an increase in diagnosis of Bang's disease (undulant fever), which in many respects strongly simulates incipient tuberculosis. Fortunately the specific serologic reaction is a strong differential point. Of great importance is the confusing picture of the respective roentgenograms of early pulmonary tuberculosis and pulmonary manifestations of undulant fever. However, the degree of diffuse involvement, rapid progression and defervescence in the case of undulant fever is a diagnostic aid. Clinically the pulse rate in tuberculosis is elevated from incipency, which is a late manifestation in Bang's disease. Both diseases show a slight degree of splenomegaly and leukopenia. The tuberculin reaction is of no great positive significance. The author concludes in suggesting an undulant fever agglutination test in any case of suggestive atypical pulmonary tuberculosis.

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FUNCTIONAL DISORDERS OF THE EXTRA-HEPATIC BILIARY SYSTEM BILIARY DYSSYNERGIA OR DYSKINESIA¹

By HAROLD A. HILL, M.D., Clinical Instructor in Radiology,
Stanford University Medical School, *San Francisco, Calif*

THE literature contains a vast number of articles on the extra-hepatic biliary system and suggestions have been made in many of the more recent references indicating the existence of definite functional disorders of this system.² The present paper is a brief review of the investigations published to date on these abnormal physiologic states.

First, it will be necessary, however, to summarize the available material relating to the normal anatomy and physiology of this system as directly related to the subject under discussion.

ANATOMY

The extra-hepatic biliary system is composed of gall bladder, ducts, and sphincter. The gall bladder is not a diverticulum, but a hollow viscus with a mean capacity of 40 c.c. There is considerable variability of the size, shape, and position of the gall bladder which is dependent upon the general bodily habitus, and the physiological status, that is, state of filling. In the hypersthenic individual the gall bladder is apt to be globular, while in the asthenic person it is usually twice as long as broad

and may be somewhat curved. It is found in the right upper quadrant in the majority of cases but in the hyposthenic type it is lower in position and may overlie the iliac crest, only very rarely is it observed on the left of the mid-line. The gall bladder may be embedded within the liver, or, at the other extreme, be completely covered by peritoneum which may extend to the liver as a mesentery-like membrane (105). The gall bladder is in contact with one or more of the following: liver, stomach, duodenum, transverse loop of the colon, and anterior abdominal wall. The wall of the gall bladder, where covered with peritoneum, consists of four coats: serous, subserous, fibromuscular, and mucous. The subserous layer is composed largely of interlacing elastic tissue. The fibromuscular coat is made up of irregularly distributed smooth muscle bundles and interwoven connective tissue (92).

The ducts of the extra-hepatic biliary system are the hepatic, cystic, and common (Fig. 1). The mucous membrane lining the cystic duct is thrown into folds, the valves of Heister, which vary in number from 0 to 24 (86). The common duct may be divided into supraduodenal, retroduodenal, pancreatic, and intramural portions. The names of the first three portions are self-explanatory as to their re-

¹ Read by title before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati, Nov. 30-Dec. 4, 1936.

² The latter have been marked with an asterisk in the bibliography.

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WILLIAM R. STECHER, M.D.

over the duct and intermingle with those of the common bile duct, thickening the wall of the intramural portion of the duct for a variable distance. This thickening does not extend around the orifice of the ampulla, but usually includes the pancreatic duct."

Similar anatomical relationships have been found by a large majority of those working on the anatomy of this region (43, 51, 52, 67, 73, 76, 79, 92, 93)

Oddi's name is most frequently used in describing the sphincter or choledochoduodenal mechanism of the intramural portion of the common duct. However, there is considerable discrepancy and confusion in the literature as to the exact structure meant thereby. Newman (89, 90) and a few others when writing of the sphincter of Oddi mean only the distal end of the intramural portion of the common duct, while another and larger group, which includes Westphal (114, 115), state that the entire intramural portion composes the sphincter. It is the latter's contention that the ampullary and papillary portions are separate reciprocal units of an expulsive and sphincteric mechanism.

The musculature of the biliary tract has both a sensory and a motor innervation, the individual muscle fibers being supplied through an intrinsic nerve plexus originating from the ganglion cells in the wall of the gall bladder (58). The vagi and the splanchnics are the nerves concerned (29, 40, 55, 67, 79).

PHYSIOLOGY

The extensive literature on the physiology of the extra-hepatic biliary tract has been reviewed and summarized several times. Mann (79), in 1924, listed 95 references, and a decade later Ivy (58) cited 553 articles. The large increase in the number of articles published on this subject between 1924 and 1934 was largely the result of investigations following the introduction of internal biliary drainage in 1919 and the discovery of Graham and Cole, in 1924, leading to the widespread use of cholecystography. The above excellent summaries being available in English, only

the physiological factors which are related to the functional abnormalities will be discussed.

The gall bladder has the four following functions

- (1) Secretion
- (2) Absorption
- (3) Storage
- (4) Pressure Regulation

(1) The mucous membrane lining the neck of the gall bladder and the valvular portion of the cystic duct normally secretes a relatively small and variable amount of mucus, which is similar in nature to that found with a hydrops of the gall bladder.

(2) The first experimental work proving that the gall bladder concentrates the bile that enters it was done by Rous and McMaster. In 1921, they showed by quantitative data that the normal gall bladder concentrates the hepatic bile entering it from four to ten times. "This is accomplished primarily by the absorption of water and inorganic ions by the cells lining the fundus and the body. The other biliary constituents appear to be absorbed only slightly, if at all" (71). This work has been confirmed (5, 53).

(3) The liver secretes from 800 to 1,200 c c per day and the gall bladder, with a mean capacity of 40 c c, would be unable to store the large amount secreted during the fasting periods were it not for its absorptive powers (5, 74). Indirectly, the gall bladder being distensible, it is possible for it to adjust itself within certain limits to the amount of bile to be stored within it. The contractility of the gall-bladder wall acts to propel the stored bile into the duodenum when needed for digestive purposes.

(4) The gall bladder is the important factor in the regulation of the pressure within the biliary tract because it can act as an expansile viscus in a tubular system which otherwise is practically rigid and, further, through its absorptive ability, it can store large amounts of the bile secreted by the liver in the periods between gastric digestion (71). The pressure-regulatory mechanism normally assures a continuation of bile secretion by preventing the

spective positions The intramural portion of the common duct passes obliquely through the duodenal wall for a distance

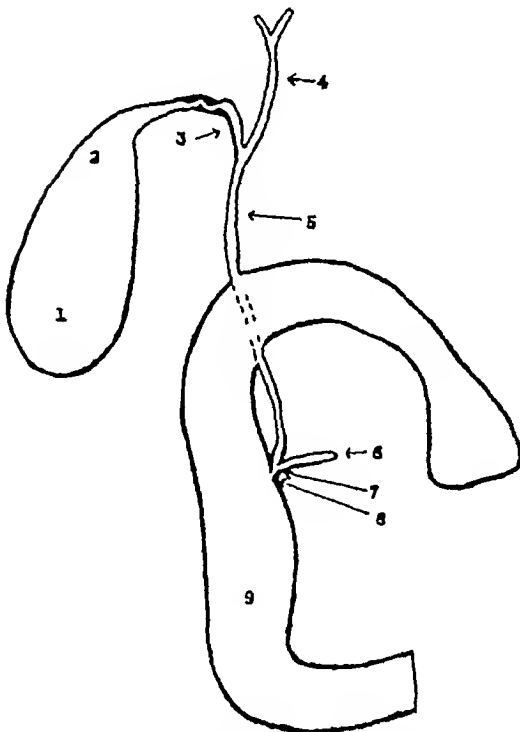


Fig 1 Diagram of the Extra hepatic Biliary System (1) gall bladder, (2) neck of gall bladder, (3) cystic duct, (4) hepatic duct, (5) common duct (6) pancreatic duct (7) ampulla of Vater (8) papilla of Vater, (9) descending duodenum

	Duct	Length		Diameter	
		Aver age	Range	Aver age	Range
I	Hepatic	3.3	0-5.4	8.5	7-14
II	Cystic	3.2	0.6-6	3.0	2.5-4
I				9.6	7-13
II	Common	6.3	3-9.5	4.0	3-5
III				5.0	

Authorities I Nuboer (92)
II Bronner (21)
III Cole (32)

of from 0.7 to 2.5 cm (92), and for the greater part of its course it runs between the mucous membrane and muscular layer of the duodenal wall (20, 31, 43, 45)

The relationship of the terminations of the common and pancreatic ducts is quite variable (83). The two ducts have been reported to open separately into the duodenum in 11 per cent of the subjects by one worker and in 26 per cent by another (76)

Usually the widened common duct is joined by the pancreatic duct to form the ampulla of Vater. The range of the ampulla in length is from 1 to 11 mm, the average diameter of the duodenal orifice of the conjoined ducts is given as 2.5 mm (76)

The common duct is supplied with very little musculature except at its duodenal termination, however, considerable elastic tissue is present in its walls. A separate musculature has been described for the ampulla and for the papilla of Vater (114)

Glisson (45) and Lütkins (68) have described a sphincter at the junction of the gall-bladder neck and the cystic duct. Lütkins states that it is present in about 75 per cent of individuals, its presence, however, has been questioned by other investigators (62, 92)

Glisson, as early as 1681, described the sphincter at the duodenal end of the common duct and the oblique passage of the duct through the wall (20, 45). He suggested that intestinal contents were prevented from entering the common duct due to its compression by the intraduodenal pressure and by the action of the circular muscle fibers about the intramural portion of the tract. In 1879, Gage (43) described the muscle fibers located about the terminations of the bile and pancreatic ducts. Oddi (93) made the first comparative study of the intramural portion of the common duct in man, dog, pig, cat, sheep, and ox. He noted that though there was considerable individual and species variation, that each species had a definite anatomical sphincter. The most complete recent paper on this subject is that one published by Giordano and Mann (83). They studied 20 species, including several species without a gall bladder, but especially the sphincteric region in man. They conclude as follows

"If the common bile duct is incised and its whole course through the duodenum is laid open, it is found that the so-called ampulla of Vater is a variable structure depending on the entrance of the duct of Wirsung into the duodenal end of the common bile duct. As the duct enters the duodenum it is surrounded by muscle fibers from the duodenum which reflect

edly many radiologists have made similar observations in the course of their work. It has been shown that the rate of gastric emptying and of passage of food through the intestinal tract does not affect the rate of gall-bladder evacuation (16, 17, 110). Studies by Sosman and his co-workers (108) on one human and three dogs following short-circuiting of the duodenum by pyloric transection and gastro-enterostomy showed that after the fatty meal the gall bladder emptied as effectively in these cases as in the normal cases not operated upon. Fats and proteins are effective stimulants to gall-bladder emptying but carbohydrates or water cause practically no evacuation of the extra-hepatic biliary tract when moved through the stomach and duodenum (14, 49, 116), yet all of these substances promote peristalsis.

The case for the passive emptying of the gall bladder by the extrinsic pressure of the stomach and the duodenum has been restated recently by the Newcomers (87, 88). The experimental findings cited in the preceding paragraph seem to me definitely to contradict the possibility of gastric and duodenal distention and peristalsis being the important factors in the evacuation of the extra-hepatic biliary tract. Furthermore, such a theory as proposed by the Newcomers is not adequate to explain the following facts:

In emptying, the longitudinal as well as the transverse diameter of the gall bladder is decreased (18, 21, 106), which would not be true if pressure exerted from the side, as by the antrum of the stomach, were the controlling factor. Likewise, completeness of evacuation has been shown to be dependent upon the amount of attachment between the gall bladder and the liver (21), other things being equal, but the degree of attachment would play no rôle if emptying were due entirely to external pressure. Neither does the Newcomers' theory explain how counter-pressure is exerted in individuals having the gall bladder connected to the liver by only a mesentery-like band. These authors claim that pressure transmitted to the gall bladder

from the distended gastroduodenal segment will cause bile to flow through the intramural portion of the common duct and into the duodenum. This cannot be so because the intraduodenal pressure exerted against the intramural portion of the common duct and tending to compress it is the sum of the pressures resulting from the contents of the duodenum plus that transmitted by the contractions of the duodenal musculature, while only the former could act on the gall bladder. Further, their theory obviously cannot explain the mechanism of gall-bladder emptying following the intravenous administration of an emulsified fatty substance (57, 116) or how cholecystokinin, which has no effect on gastric motility and a variable effect on duodenal peristalsis, promotes evacuation of the gall bladder (37, 54, 56, 57).

Boyden's (18) phases of gall-bladder evacuation are interpreted by the Newcomers on the assumption that the full stomach straightens the cystic duct. If their assumption were correct, the stomach would have to be distended in order that the gall bladder might fill. They also have made the statement that, "Straightening of the cystic duct after eating allows some gall bladders to fill and empty normally after eating" (87). Clearly this cannot be the reason that some gall bladders are visualized only after the fatty meal inasmuch as the gall bladder cannot fill and empty at the same time. Also in Bronner's (21) studies of the ptotic gall bladder he has pointed out that there is an acute angulation of the cystic duct which it is impossible to straighten out by distention or peristalsis, yet the gall bladder empties fairly well.

The positive evidence for concluding that the gall bladder is emptied by the intrinsic force of its own musculature is as follows:

(1) Anatomically, the amount of musculature is adequate and its reticular arrangement favors contractions in all directions, that is, constricting contractions (17, 23, 29, 51, 57, 73, 106, 116).

(2) Spontaneous contractions have been reported (1, 39, 94).

pressure in the biliary tract from exceeding the maximum secretion pressure of the liver (72, 74), possibly the pancreas is similarly protected

The preservation of the sphincteric action of the intramural portion of the common duct is another important rôle played by the pressure-regulating mechanism, an abnormally increased intraductal pressure, as occurs following cholecystectomy, usually leads to an incontinent sphincter. The relaxation of the sphincter in such cases would seem to be a protective mechanism in that it undoubtedly helps prevent pressure atrophy of the liver and pancreatic cells. It has been noted that an abnormally contracted sphincter may result in bile, pancreatic juice or both being backed up in the ducts. This may lead to a pancreatitis when bile is forced into the pancreatic ducts (2), to dilatation of the intrabiliary ducts and pressure atrophy of the liver (36) and, in cases in which the pancreatic ferment is forced into the biliary tract, there ensues a chronic inflammation or necrosis with a possible perforation of the gall bladder and bile peritonitis (105, 115).

The hepatic ducts, lower cystic, and all of the common duct except its intramural portion may be dismissed briefly as they normally act only as tubes for the passage of the bile, they have no concentrative function. There is an individual difference in the size and the number of the folds, or valves of Heister, in the cystic duct and, accordingly, the time taken by the bile in passing through this region is variable. The valves, however, probably have no significant regulatory function (86). The intramural portion of the common duct is definitely motor in function, as described in the following section.

MOTOR FUNCTIONS OF THE EXTRA-HEPATIC BILIARY SYSTEM

The motor functions of the extra-hepatic biliary tract have been denied by a small number of workers, including Blond (13), Halpert (48), and Sweet (109). They contend that the gall bladder is emptied only

by the resorption of its contents. This view of complete absorption of all of the bile from the gall bladder has been settled in the negative, however, especially since the advent of cholecystography (53).

Another small group state that the outflow from the gall bladder is due to extrinsic forces. They (5, 25, 26, 34, 35, 46, 119) cite as causative agents one or more of the following factors: "respiratory squeeze," intra-abdominal pressure, recoil of the elastic wall of the distended gall bladder, flushing action of the hepatic bile, and/or the milking or pumping action of duodenal peristalsis on the common duct. These workers also deny the existence of a sphincter at the duodenal end of the common duct, claiming instead that the regulatory action is due entirely to tonus and peristalsis of the duodenum (7, 24, 28, 34, 37, 46, 116). The latter opinion was held by practically all of the early workers until the time of Oddi (20), just as most of them thought that the gall bladder was emptied by pressure of the antrum of the stomach (14).

The majority of the modern investigators, however, maintain that the important factors involved in the filling and emptying of the extra-hepatic biliary tract are intrinsic (1 to 4, 8, 14 to 20, 21, 23, 29 to 33, 38 to 41, 45, 46, 50 to 60, 64 to 69, 71, 73, 74, 76 to 85, 89 to 93, 96, 98 to 108, 110, 112, 114, 119). Masterly experiments have been conducted by Boyden (17, 18), Higgins and Mann (80, 81), Elman and McMaster (74), and by Puestow (98) in such a manner that all of the extrinsic factors have been excluded. It has been shown in each and every instance that evacuation was dependent upon the intrinsic musculature of the extra-hepatic biliary tract. Whitaker (116) found that the amount of gall-bladder emptying was inversely proportional to the degree of experimentally induced damage to the gall-bladder wall. He also showed that a barium meal could be moved by peristalsis through the entire intestinal tract without causing a discharge of bile. Boyden (16) and Bronner (21) have confirmed this finding in man, and undoubt-

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are prevented from entering the common and pancreatic ducts by the sphincter of Oddi (2, 76). The ampulla of Vater is visualized, however, in a small percentage of all individuals having gastro-intestinal studies, but there is no reflux of barium into either the common or pancreatic ducts in these cases. If Westphal's conception of the sphincteric mechanism is accepted, the above findings may be explained on the basis of a relaxed or incontinent papillary muscular ring with a contracted ampullary sphincter. The latter condition was noted by Westphal following stimulation of the vagus (114).

The intraduodenal pressure resulting from the duodenal contents and the tonus of the duodenal wall is undoubtedly an accessory factor in the regulatory mechanism of the intramural portion of the common duct (37). Coffey's (31) observations made following different methods of surgical implantation of the common bile duct bear this out. When placed directly into the wall of the duodenum, there was a marked reflux of duodenal contents into the common duct and gross dilatation of this structure. When, on the other hand, the duct was obliquely implanted between the muscular and mucosal layers of the duodenum, it apparently worked like a check-valve for no dilatation of the duct occurred. Coffey stated that the success of the indirect method of implantation was due to compression of the duct by the intraduodenal pressure. The principle has also proved practical in transplantation of the ureter into the colon.

There is a double innervation of the musculature of the extra-hepatic biliary tract (6, 39, 40, 57, 66, 69, 74, 79, 82, 83, 85, 98, 114). The muscular tissue may function independently of any innervation (116)—so may the intestine. However, the vagal and splanchnic fibers which are distributed to the biliary tract undoubtedly exert a control over the normal emptying of the extra-hepatic biliary tract (55). The stimulation of the vagal fibers causes the gall bladder to contract, similarly the splanchnic fibers are inhibitory (79, 114).

The musculature of the gall bladder and that of the sphincter being antagonistic (8, 106), their regulation is best explainable on the basis of a reciprocal innervation (5, 74, 82). The active force in the emptying of the gall bladder appears to be a reflex mechanism which is stimulated by the presence of protein or fatty food, especially the latter, in the duodenum (18, 98, 116). This mechanism is subject to reflexes originating in disorders of the abdominal and pelvic organs as, for example, appendicitis, peptic ulcer, and ovarian disease (19, 83).

The chemical substances which affect the evacuation of the extra-hepatic biliary tract are many. The fact that the threshold of stimulation of the sphincters shows considerable variability makes it difficult to assay the activity of the various stimulants. Fatty and protein foods probably act as a chemical stimulus rather than as a mechanical one. Ivy's secretin-free hormone, cholecystokinin (56, 57, 103), produced by the duodenal mucosa on contact with fats (and proteins), is apparently the physiological stimulant. The glandular secretions undoubtedly affect the motility of the biliary tract since the hormones act on the sympathetic and parasympathetic systems (58, 115). Little is known regarding the changes produced by the different secretions but there are indications that hyperthyroidism and hypoparathyroidism tend to induce spasticity of the sphincters of the gastro-intestinal tract.

There are many contradictory opinions as to the actions of the various drugs on the extra-hepatic biliary tract (2, 5, 6, 15, 18, 24, 27, 30, 32, 50, 58, 66, 67, 69, 73, 82, 83, 89, 98, 105, 114, 115, 116, 119). Contraction of the gall bladder is promoted by acetylcholine, barium chloride, histamine and pilocarpine, chloral hydrate, ergotamine, and strophanthin increase its tonus. Atropine, epinephrine, ether, magnesium sulphate, the nitrites and papaverine tend to relax the gall bladder. The bile salts, caffeine, codeine, morphine, nicotine, physostigmine, pituitrin, potassium chloride, and sodium citrate are either ineffective in

(3) Tonic and rhythmic contractions have been shown by tracings to be present (6, 17, 39, 58, 92, 95, 110) They are unaffected by tonus changes and peristalsis in the duodenum (26, 82)

(4) Mechanical, chemical, or electrical stimulation of the gall bladder has been followed by observable contractions (17)

(5) It has been shown by roentgenological methods that accompanying a decrease in the size of the gall bladder after the fatty meal there are (a) definite changes in its shape explainable only on the basis of contraction of its musculature (15, 21), and (b) that there is a filling of the cystic duct and common duct in many cases (21, 57) Bronner (21) claims that in individuals in whom the biliary tract empties rapidly the cystic duct is visualized in practically all cases, the common duct in from 80 to 90 per cent, while in slowly emptying or hypomotile types, the respective figures for the two ducts are 65 and 25 per cent

The investigators supporting the active rôle of the gall-bladder musculature in the emptying of this viscus also conclude that there is an intrinsic sphincteric mechanism present at the duodenal termination of the common duct which regulates the filling and emptying of the gall bladder The following evidence is given in proof of the above conclusion

(1) A definite sphincter has been demonstrated anatomically (5, 20, 33, 43, 51, 52, 67, 78, 83, 84, 89, 92, 114)

(2) The filling of the gall bladder is dependent upon an intact sphincteric mechanism (75, 98, 107), if the sphincter is incised or cannulated, the gall bladder does not fill (116, 119)

(3) In species without a gall bladder and in most post-cholecystectomy cases, no regulatory action is present, however, in species with a gall bladder while there is also a continuous secretion of bile by the liver, the discharge into the duodenum occurs only intermittently or by spurts (2, 83, 98)

(4) When duodenal peristalsis is present the discharge occurs during relaxation of the duodenum (34, 65, 67, 74, 98) which is

taken to mean that the two processes are correlated rather than indicating that changes in duodenal tonus are required in order for the bile to pass into the duodenum If duodenal motility were responsible for emptying of the biliary tract, then the ducts should not dilate after removal of the gall bladder as occurs in most instances (5, 36, 63, 71, 74, 77, 79, 83, 89, 93, 101) Incising the sphincter prevents this dilatation (71, 77, 89, 101)

(5) Mechanical irritation of the duodenal papillæ in species with a gall bladder inhibits the flow of bile into the duodenum for a variable period, after which a large amount of bile may be discharged without any visible change in the tonus of the duodenal wall (2, 83)

(6) The intramural portion of the common duct is capable of withstanding a minimal intraductal pressure of from 75 to 100 mm of water, although there is marked individual variability (2, 32, 60, 74, 77, 82) Atropine may decrease the intramural resistance without affecting duodenal tonus (67) This intramural resistance is usually decreased following cholecystectomy and as a result the bile drains continuously into the duodenum (77, 82, 98, 101, 107)

(7) Westphal (114) and later Lueth (67), as a result of their investigations of the intramural portion of the common duct, divided it into two parts The resistance noted by them at the papilla was equal to from one-sixth to one-third of the total, the major portion of the resistance was found at a higher level, the ampullary region, and responded to stimulation of only a small area proximal to the entrance of the pancreatic duct Westphal (114) suggested a reciprocal action and innervation of the two portions He found that stimulation of the vagus resulted in relaxation of the papillary sphincter and contraction of the ampulla, while exactly the opposite results were obtained by stimulation of the splanchnics Lueth (67), Newman (89), Nuboer (92), and Westphal (114) mention a possible ejaculatory function of the choledochoduodenal mechanism

(8) Intestinal contents and parasites

(a) *Hypermotile type* Increased motility of the gall bladder and ampulla with rapid emptying

(b) *Hypertonic type* Contraction of the gall bladder against spasm of the sphincter, resulting in distention and pain

II Atonic Type

Relaxation or atony of the gall bladder with spasm of the papillary sphincter. This causes distention (atonic) of the gall bladder and a heavy, aching sensation in the biliary region

Pavel (96) objects to the use of the word "dyskinesia" to designate all of the abnormal functional conditions of the extra-hepatic biliary tract, because he states that it tends to confuse the picture from both a theoretical and a practical standpoint. He does not consider the clinical pictures of the different types sufficiently characteristic to enable one to differentiate between them.

Pavel lists the possible disorders of motility as follows

(1) Those due to augmentation of the power of evacuation of the gall bladder,

(2) Those due to a diminution or loss of this power,

(3) Those due to an augmentation of the sphincter of Oddi,

(4) Those due to a lowering of the tonus of the sphincter, and

(5) Those due to a defective correlation between bladder and sphincter

He states, further, that all these disturbances must be divided into those of nervous and those of muscular origin. Since some of these states have only a theoretical importance and are without diagnostic possibilities, Pavel offers a simpler classification. He believes that the three following conditions may be differentiated by the clinical and laboratory findings characteristic of each and by the therapeutic measures which are effective in each type

(1) A condition in which augmentation of the power of contraction of the gall bladder under abnormal stimulation of the

vegetative nervous system leads to biliary colic. The clinical picture of this condition is sufficient to make the diagnosis

(2) Hypotonic and atonic conditions of the gall bladder, the diagnosis of which can be made easily by means of duodenal intubation and cholecystography. He says that the treatment is well established and efficacious

(3) Disorders due to spasm of the sphincter of Oddi which have a very definite symptomatology as well as a definite treatment régime

The abnormal functional states were divided into two groups, "spastic distention" and "atonic distention," by Newman (89). He has taken exception to the neurological concept proposed by Westphal, believing instead that these disturbances are due to

"constitutional and acquired factors, like other diseases, but the disorders of motility behave as if disordered innervation were the final common path by which the causes act. I would like to stress that any division of the dyskinetic states into hard and fast entities is artificial, there is a continuous series of stages of departure from normality, to which different cases correspond, and the same case may show different degrees of the process at different times"

Later (91) he says,

"I have found 'atonic' distention much less common than I had thought, and I doubt whether it exists save as part of the anxiety neurosis of the menopause or as a senile phenomenon"

Psychical influences, infrequent feedings, and abstinence from protein foods have been listed by Meltzer (85) as three possible factors accounting for hypertonic disorders. Lyon (69) uses the terms "spastic" and "atonic dysfunction" to describe the functional biliary disorders. He supports Westphal's theory of etiology and suggests that there is possibly a unity of the functional disorders of the gastro-intestinal tract and its appendages since they have a common innervation. Held (50) has proposed using "cholecystopathica atonica" and "cholecystopathica hypertonica" for these disorders of function which he sug-

the usual dosages employed or their action is still a matter of controversy. Acetylcholine, alkali, muscarine, and pilocarpine excite the parasympathetic system and thus increase the tonus of the cholechooduodenal mechanism, while acid, adrenalin, and magnesium sulphate decrease the tonus of the sphincter by paralyzing the parasympathetic system (27). Codeine, dilaudid, morphine, and pantopon are apt to produce spasm of the sphincters, relaxation has been obtained by using amyl nitrite, glyceryl trinitrate, and theophylline ethylenediamine (27). The following drugs have little or no effect upon the sphincters: atropine, ephedrine, ergotamine tartrate, and papaverine.

The ability of any drug to empty the gall bladder is dependent not only upon its action on the gall-bladder musculature but also on the cholechooduodenal mechanism. Furthermore, some substances, such as the bile salts, increase the flow of bile but do not empty the gall bladder.

PHYSIOLOGICAL DISORDERS OF THE EXTRA-HEPATIC BILIARY TRACT

Oddi (93), in his paper on the anatomy and the physiology of the extra-hepatic biliary tract published in 1877, suggested that biliary colic and jaundice might be due in some cases to spasm of the sphincter at the duodenal end of the common duct. Krukenberg, in 1903, and Borghi, a decade later, published clinical records of patients having gall-bladder colic who at operation showed neither infection nor stones (50, 59). The symptoms in such cases usually

have been explained in the past on the basis of either adhesions or inspissated bile.

The next step in the evolution of the idea of functional abnormalities was the result of studies on the stasis gall bladder. Aschoff and Bacmeister (3), in 1909, described two types of "Stauungs-blasen": the atrophic and hypertrophic, the respective altered conditions of the muscular walls being present in the absence of infiltration or calculi. In 1920, Schmieden (104) explained the stasis present in such cases as due to a kinking of the junction of the gall-bladder neck and the cystic duct. Two years later, John Berg (8) stated that biliary stasis might be due to a functional disorder and cited as confirmatory evidence the finding of hypertrophied muscular tissue surrounding Vater's ampulla. Similar findings were reported later by Giordano and Mann (83), Newman (89, 90), Nuboer (92), and Westphal (114).

Meltzer (85) suggested, in 1917, the possibility of spasm of the sphincter of Oddi as a cause for biliary colic. The greatest impetus to the conception of the functional disorders, however, has been due to the work of Westphal (114, 115). His results on innervation studies in cats and guinea pigs are recorded in Table I.

Upon the basis of these findings Westphal (114) classified the functional disorders of motility of the extra-hepatic biliary tract into the following types:

I Hyperkinetic Type

The difference between the subtypes is dependent upon the degree of hypertonicity present.

TABLE I

Nerve Stimulated	Type of Stimulation	Reactions of the			Clinical Type of Response
		Gall Bladder	Ampulla V	Papilla V	
Vagus below the diaphragm	Weak electrical current	Contracts	Peristalsis manifest	Relaxes	Normal
Vagus below the diaphragm	Stronger	Tone increase, empties rapidly	Movements of ampulla very lively	Not stated	Hypermotile dyskinesia
Vagus below the diaphragm	Very strong	Contracts	Spasm	Not stated	Hypertonic dyskinesia
Splanchnic	Not stated	Relaxes	Relaxes	Spasm	Atonic dyskinesia

due presumably to biliary dyskinesia Best and Hicken (12) state, "We have found spastic biliary dyssynergia in 15 per cent of the patients in our series of 75"

Although there are many more cases reported in the literature (Bronner, 21, cites two cases, Bufano, 22, one, Overholt, 94, several, Newman, 89, twelve, and Rossi, 100, one), the figures on incidence are rarely given

CLINICAL FINDINGS

The clinical picture of the spastic and atonic types of functional disorders of the extra-hepatic biliary tract have been presented in detail by Newman (89, 90) and

single cause (69, 70, 75) has led to the increasing use of cholecystography to investigate the upper abdominal disorders. The value of cholecystography is increased if examinations are made following a fatty meal. The rate of gall-bladder evacuation following the fatty, or Boyden, meal (14) is normally quite variable (2, 20, 23), the average being about one and one-fourth hour (18, 21, 58). The time of emptying is about the same in children and adult females but takes about twice as long in the adult male (18). Other things being equal, the larger the gall bladder, the longer it takes to empty (18). In peptic ulcer cases the rate is apt to be very rapid (21).

TABLE II

Characteristic	Hypertonic Type	Atonic Type
1 Sex	Females predominate	Females predominate
2 Age	Average at onset is 36	Older
3 Bodily habitus	Hypersthenic	Hyposthenic
4 Pain		
(a) Character	Dull, similar to mild gallstone colic, spasmodic	Heavy aching sensation, continuous
(b) Time of onset	An hour or two after meals	Soon after eating
(c) Radiation	To left and to back	To epigastrium
5 Nausea	Very common	Rare
6 Vomiting	Occasionally	More often
7 Jaundice	Subicterus has been reported during attacks	Questionable if ever present
8 Bowel activity	Tendency to diarrhea	Apt to be constipated
9 Tenderness	Over gall bladder area	Over epigastrium and liver
Intubation Findings		
1 Stomach	High acidity	Low acidity
2 Duodenum	Little bilirubin	Some bilirubin
(a) Response to oil	Good after prolonged latent period	Slow flow after long pause
(b) Response to pilocarpin	Delay up to five minutes	Flow without latent period
(c) Evidence of infection	None	None

There is no pathognomonic symptom, sign, or syndrome of either type of dysfunction. In fact, every case is apt to present exceptions to the above listed characteristics (89).

Westphal (114, 115) A brief summary of their findings is presented in Table II

ROENTGENOGRAPHIC FINDINGS

The realization of the fact that diseases of the biliary system are probably responsible for more cases of epigastric distress or gastro-intestinal dyspepsia than any other

In cases of dyskinesia the rate of emptying may be within normal limits, but if altered is usually delayed

Serial studies after the Boyden fatty meal may be of considerable aid in diagnosis, Bronner (21) has reported one case in which the common duct proved to be as wide as the gall-bladder shadow and an-

gests are due to disturbances in the vegetative nerves controlling the motor functions of the gall bladder and the antral and papillary portions of the sphincter. It has been noted clinically that neuromuscular dyskinesia of the extra-hepatic biliary tract occurs more frequently in pregnancy, during menstruation, or with psychic emotional states, that is, in individuals with an abnormal vagal stimulation (105, 115).

Loss of function and spasm are suggested by Giordano and Mann (83) as the two possible abnormal functional conditions of the sphincteric mechanism of the common duct. They state that the former may be due to a lesion of the gall bladder which causes it to cease functioning when the condition present would be analogous to that found after cholecystectomy. Spasm, they believe, may be initiated by reflex stimulation of the sphincter by a pathological lesion in one of the abdominal viscera. For example, it is pointed out by them that the musculature of the sphincter has been found to be hypertrophied in some cases of peptic ulcer, cholecystitis and pancreatitis.

Boyden (18), following his investigation of the phases of gall-bladder evacuation, described the three following types of biliary-tract response.

(1) The most effective type in which a stimulus results in a simultaneous contraction of the gall bladder and a relaxation of the sphincter. This produces the greatest flow in the shortest time and is to be considered typical of the normal response.

(2) A relatively rare type in which the stimulus causes a relaxation of the gall bladder and sudden closure of the sphincter. This produces a temporary delay in emptying.

(3) In the sluggish type there is a momentary emptying followed by slow filling, which, in turn, is followed by slow emptying due presumably to a hypertonic sphincter.

Ivy and Sandblom (59) show that the intramural portion of the common duct can contract sufficiently to prevent evacuation of the contracting gall bladder. In proof

of the fact that the resulting increased intrabiliary pressure may produce pain in the non-inflamed biliary tract, they offer two observations, the first by Westphal who passed a tube into the duodenum and, with the aid of olive oil, obtained an out-flow of bile. Injection of pilocarpin resulted in cessation of the bile flow and frequently produced biliary distress which could be relieved by atropine. Ivy and his co-workers made the second observation during their investigations of the normal responses to cholecystokinin. In a normal individual, bile was obtained by duodenal drainage, then the flow stopped without evidence of distress. Administration of cholecystokinin was followed by a copious flow of pancreatic juice but no bile, after which biliary distress soon ensued and became progressively worse. Finally, it was necessary to pass magnesium sulphate into the duodenum, in order to control the colic, after which bile was again obtainable from the duodenum. The authors contend that there was an abnormally contracted sphincter and that magnesium sulphate relaxed the spasm, as proposed by Meltzer (85).

Best and Hicken (9 to 12) have reported five cases of dysfunction of the choledochal sphincter. They prefer the term "dys-synergia" which Dorland defines as a "disturbance of muscular co-ordination", by "dyskinesia". Dorland signifies an "impairment of the power of voluntary movement."

INCIDENCE

Westphal (115) reported an incidence of 5 per cent of cases exhibiting spasm of the sphincter of Oddi. A 25 per cent incidence of spastic dyskinesia in stoneless cholangiopathic cases was given by Umber (112). Aschoff (4) recorded that in 215 cholecystectomy cases there were 25 free of stones and that seven of the latter exhibited symptoms which were thought to be due to functional disorders of the biliary tract. In a series of 19 normal individuals studied, Ivy and his co-workers (59) found three subjects who complained of biliary distress.

tis, cholangitis, cholecystitis, duodenitis, pancreatitis, appendicitis, and colitis,

(4) Miscellaneous disturbances, as, for example, functional disorders of the stomach or colon, or nervous dyspepsia

TREATMENT

The treatment of the functional disorders has been worked out on the basis of the alterations in the tonicity of the system

Hypertonic Type—Newman (89) recommends the following for cases of spastic distention "small, equal, and regular meals, and avoidance of mixtures of fats and starches" The drugs he uses are belladonna and sodium bicarbonate He suggests that a guarded prognosis should be given in these cases since they may be associated with a neurasthenia or with an anatomical kink (91) Lyon (69) advises the same régime plus duodenal drainage Held (50) thinks that the instillation of 25 per cent magnesium sulphate into the duodenum and the application of heat are helpful measures Atropin, papaverin, heat, and regulation of the diet are advocated by Schmieden and Niessen (105)

Atonic Type—It has been recommended that the patient avoid doughy foods and fluids with meals, fruits and salads are allowed and also acid in various natural forms is given after meals (90) Kalk and Schondube (64) suggest the use of pituitrin, but Newman (89) believes this substance is contra-indicated Westphal (115) advocates using small doses of strychnine, Schmieden and Niessen (105) advocate the use of menthol, salicylates, cholecystokinin, or secretin Lyon (69) advances the following three-item plan

(1) Full fat diet, four meals a day with no skipping,

(2) Oleic acid and drugs to relieve pylorospasm if it is also present,

(3) Biliary drainage

Without distinction as to type, the following measures have been presented as being efficacious in relaxing a spastic sphincteric mechanism at the duodenal termination of the common duct

(1) The removal of any reflex cause, as, for example, appendicitis

(2) The use of the nitrites, especially amyl nitrite or glyceryl trinitrate, and the avoidance of codeine, dilaudid, or morphine (27)

(3) The use of warm oil on the choledochal side of the sphincter in cases operated upon that have a tube in the gall bladder or common duct (9-12)

(4) "Endocholedochal sphincterotomy" has been performed in cases of spasm of Oddi's sphincter (33)

(5) Dilatation of the sphincter, anastomosis of the gall bladder and stomach or intestine, cholecystectomy with choledochoduodenostomy, or the latter alone, are other operative procedures which have been used to relieve patients of their dyskinetic symptoms (105, 115)

DISCUSSION OF REPORTED CASES

There is a considerable literature (see bibliography) dealing with the subject of functional disorders of the extra-hepatic biliary system, yet the number of reported cases is relatively small and the majority of these are of the hypertonic or spastic type In general, the reports include but few details of the case records, very brief or no consideration of the differential diagnostic points, meager or no descriptions of the operative findings and of the responses to therapy, and practically no statistical information

Best and Hicken (9, 10, 11) have reported in some detail 15 cases in which cholangiographic studies were made by them Ten of these are listed as "controls" because the radiopaque oil which was instilled into the gall bladder or common duct flowed immediately into the duodenum The remaining five cases are reported as examples of biliary dyssynergia because in each instance there was an "evanescent obstruction" to the outflow of the oil, due, according to the authors, to a spasm of the sphincteric mechanism of the intramural portion of the common duct In over fifty cases examined by them at the operating table, at which times the patients

other in which the diameter was half as great but still was above normal limits. These cases exhibited typical biliary distress and no organic lesion was found at operation. Newman (89) and Westphal (115) have made similar observations. The x-ray findings in dyskinesia, as given by Newman (89) and Westphal (115), are summarized in Table III.

During the last decade, there have been published several articles advocating the use of cholangiography at the operating table or following operations upon the biliary system whenever the cause for the biliary symptoms is obscure (42, 44, 63, 94, 97, 107, 111). Best, Hicken, and Hunt (10) cite its usefulness not only in diagnosing organic lesions, such as stones,

teetomy cases which have no external fistula or tube in the duct.

DIAGNOSIS

The diagnosis of the functional disorders of the extra-hepatic biliary tract is far from simple. Disturbances of secretion, absorption and some of the motor disorders are not diagnosable at present. The hypertonic and atonic types of dyskinesia or dyssynergia may be detected only by a correlation of a carefully taken history with the findings obtained from duodenal intubation and roentgenological studies. Before a diagnosis of a functional disorder is made, any possible organic explanation of the symptoms must be excluded. Furthermore, I do not believe that those cases

TABLE III

Roentgenological Characteristics	Hypertonic Type	Atonic Type
1 Concentration	Normal	Poor
2 Size	Normal	Long and thin
3 Emptying after fatty meal	Delayed	May be delayed
4 Ducts dilated	Reported in some cases	Probable though none reported
5 Stomach	Hypersthenic and empties rapidly unless there is associated pylorospasm	Hyposthenic and empties slowly

strictures, and mucous plugs, but also in detecting functional disorders. They consider an evanescent obstruction to the outflow of the opaque medium which is instilled into the gall bladder or common duct as sufficient to warrant the diagnosis of biliary dyssynergia in those cases with a history of continuing or recurring biliary distress.

The results of attempts to visualize the bile ducts by the repeated administration of many small doses of the opaque gall-bladder salt and glucose in patients who have had their gall bladders removed are as yet not conclusive but are sufficiently promising to warrant further study of this method (38). The improvement of this method may make it possible to diagnose organic and functional disorders of the common duct and sphincter of Oddi by roentgenological methods in post-cholecys-

presenting spasm of the sphincter on a reflex basis, that is, in which the spasm is initiated by an organic lesion of one of the abdominal viscera, can be classified as true examples of biliary dyskinesia. In such patients, the spasm will be relieved when the lesion causing the abnormal biliary symptoms is cured.

The following conditions should be considered in the differential diagnosis of the dysfunctions of the extra-hepatic biliary tract.

(1) Congenital dilatation of the common duct, which may be enormous (105, 120), must not be confused with dilatation due to spasm of the sphincter.

(2) Obstructive lesions of the biliary ducts due to strictures, kinks, mucous plugs, and inspissated bile and as a result of external pressure on the ducts.

(3) Inflammatory lesions such as hepati-

function By far the majority of investigators, however, support the contrary school of thought which contends that the proper functioning of the extra-hepatic biliary tract is in large measure dependent upon its intrinsic musculature

It seems unlikely that a hollow viscus, such as the gall bladder, with walls containing smooth muscle of adequate amount to empty it, would not be able to expel its contents through the contraction of its walls Furthermore, there is experimental and clinical proof that gall-bladder evacuation is dependent upon intrinsic forces, and that the intramural portion of the common duct is an important sphincteric mechanism concerned with evacuation The intraduodenal pressure acting upon that portion of the common duct lying beneath the duodenal mucosa is probably an accessory factor in the regulation of the choledochoduodenal mechanism

The gall bladder and sphincter of Oddi are correlated in their activities by a common innervation so that the gall bladder may fill with bile, store the same until needed, and then slowly discharge it into the duodenum during the period of digestion The three important factors upon which the discharge of bile depends are the secretory pressure of the liver, the contractility of the gall bladder, and the sphincteric action of the intramural portion of the common bile duct

From the evidence available to date, it would seem that functional disorders of the extra-hepatic biliary tract are relatively rare, especially if those due to associated organic lesions are excluded The physiological disturbances that can be diagnosed are the hypertonic and atonic types of motor disorders—the former is more frequent and is usually exhibited as a spasticity of the sphincteric mechanism

The symptoms of the spastic disorders are similar to those of a case of mild gall-stone colic, while a case of gastro intestinal dyspepsia is simulated in the atonic forms of dysfunctioning

The diagnosis depends upon a careful correlation of the findings of the history,

duodenal intubation, and roentgenological studies The most significant cholecystographic evidence is found only if serial studies are made following ingestion of the fatty meal At present, definite precautions must be observed in evaluating the cholangiographic findings because sufficient experimental investigation has not been undertaken in order to determine the range or variability of the normal responses

Treatment of the different disorders is both medical and surgical, final standardization of definite therapeutic régimes is a matter of the future

Criticism of the reported cases of biliary dyskinesia or dyssynergia has been made not so much to deny the existence of the functional disorders as to be an incentive to additional and more critical studies of the extra-hepatic biliary system

450 Sutter St

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were under the influence of spinal anesthesia, there was no immediate discharge of the oil into the duodenum (12)

In practically all of their 15 cases, the symptoms present and the dilatation of the common duct as well as the transient delay in emptying present only in the five "dys-synergic" cases are explainable by the gross pathologic lesions found at operation or on a basis of the operative procedures undertaken. Infection, stones, or both were found at operation in the five cases exhibiting evanescent obstruction to the outflow of the instilled oil, furthermore, the gall bladder had been or was removed in four cases, drained in the fifth. The common duct was found to be dilated at operation in four, was explored in five, and a tube was inserted into the common duct in four cases (9-11)

It has been shown that after cholecystectomy, "the process producing dilatation of the ducts is maintained until the biliary tract will contain as much bile as the gall bladder, or more often, until the sphincter itself becomes dilated and is not able to withstand its normal pressure" (77). It also has been noted that immediately following the removal of the gall bladder the sphincter is paralyzed (59, 77, 119). The sphincter remains hypotonic afterward, regains its former tonus, or becomes spastic (65, 101). Dependent upon the nature of the end-result, the discharge of bile will be either a continuous dribble or occur by spurts (83, 98, 101). This variability of responses will satisfactorily explain the fact that Best and Hicken found ten of their cases which discharged the oil immediately and five which showed a transitory or evanescent delay of the outflow. In their "control" cases the open, relaxed, or hypotonic sphincter allowed the oil to drain out immediately, in the five other cases the tonus of the sphincter was regained sufficiently to hold the oil back in the ducts long enough so that the latter could be visualized. Bronner (21) has reported a filling and visualization of the ducts in a large percentage of normal cholangiograms. Therefore, if Best and

Hicken are correct in the interpretation of their findings, spasm would have to be present in all cases in which the cystic and common ducts are visualized following the fatty meal. This seems to me to be very unlikely.

In several of their reported cases, the spasm supposedly present has been relaxed and has remained so following the single instillation of warm oil on the choledochal side of the sphincter. As a rule, spasm of the other sphincters of the gastro-intestinal tract, unless psychic, does not disappear permanently with comparable treatment. In fact, these results suggest the washing out of a small plug of mucus or inspissated bile by the oil instilled into the common duct rather than spasm.

SUMMARY AND CONCLUSIONS

This paper is presented in the hope that a better understanding of the normal and abnormal anatomy and physiology of the extra-hepatic biliary tract will result in better diagnoses and more efficacious treatment of the various biliary disorders. In the past, the functional disturbances received little or no attention, and because of this, unsatisfactory end-results of the different forms of therapy were all too common. Many different explanations have been given at various times to account for the persistence of the old symptoms or for the new complaints arising following operations upon the extra-hepatic biliary tract. Adhesions, anatomical kinks, plugs of mucus or inspissated bile, strictures or external pressure undoubtedly have been responsible in the majority of such cases for the patient's complaints. In the remainder, the symptoms were not accountable for on the basis of the above organic lesions. They are explainable, however, by the presence of functional disorders, most of which are disorders of motility.

A few workers have denied the gall-bladder musculature any motility and though some of these workers admit the existence of a sphincteric mechanism at the duodenal termination of the common bile duct, they all deny it any significant

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CRANIAL DYSPLASIAS OF PITUITARY ORIGIN¹

By HECTOR MORTIMER, GEORGE LEVENE, and ALLAN WINTER ROWE*

From the Department of Biochemistry, McGill University, Montreal, Canada, and the Evans Memorial for Clinical Research and Neuro-endocrine Research, Boston

PART II

THE EXAMINATION OF CRANIAL SKIAGRAMS AND THE DYSPLASTIC TYPES FOUND

AT THE time this work was undertaken, there had been studied by Rowe and his colleagues some four thousand cases, in which, after a thorough investigation (†), a diagnosis had been arrived at. Many of them had been studied for more than one period, in the course of several years, and amongst these were some in whose cranial skiagrams changes could be seen to have occurred with the passage of time, this was of special value in the case of children and adolescents.

Although routine skiagrams are taken in all cases, it was to be regretted that many of the earlier films had been destroyed, but there remained for study skiagrams of 2,950 cases. In each there was, in addition to a lateral skiagram, a postero-anterior view taken in the Caldwell position, which projects the shadow of the petrous portion of the temporal bone into the lower part of the orbit and upper part of the maxillary antrum. In this latter position, therefore, the frontal sinuses, nasal fossæ and septum, and the greater part of the maxillary antra can be seen clearly.

The films were studied, only the age and sex of the patient being known. No case was classed as abnormal unless two observers were of that opinion. The details upon which the opinion was based were recorded, and, thereafter, the final case-diagnosis was supplied, and the cranial findings discussed in the light of the full history and physiological data available.

Standards of Judgment in the Examination of Cranial Skiagrams—In view of the wide

variations in size and proportions in human crania that are known to occur, apart from the great differences indubitably due to age, sex, family, race, environment, and disease, and looking on the skull as a record, not only of dimensional growth, but more especially of development, the necessity at once arose of deciding on what evidence it might reasonably be assumed that there was present, in a given case, such a variation, in pattern or dimension, from what is currently found as to be significant of disturbance of the growth-controlling processes in that individual.

It was obvious, of course, that such evidence could not be estimated with any high degree of accuracy, could in no sense be "craniometric," in view of the nature of the material under survey. The cranial skiagram as a basis of judgment could be expected to serve only as an approximation, distortion to some extent being inevitable. There are, however, advantages which more than counterbalance the defects. The skiagrams were records of patients studied in the past, who in the great majority of cases could not be reached again for craniometric study, and as a clinical method of securing data, in its ease and rapidity, it was preferable to the tedious and highly specialized technique of craniometry. There was even an advantage in not seeing the patient personally, in the avoidance of the acquisition of clinical impressions from other sources, which might have biased judgment. The chief advantage, however, lay in the fact that the roentgenologic examination is the only method by which, in the living, architectural structure can be seen and the degree of calcification reliably estimated. Also, relative proportions in size, in deeply placed structures, not susceptible to craniometric measurement, be-

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* Deceased Dec 6 1934

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increase in size of the face is at least three times as great as the increase undergone by the brain-case, so that their velocities of growth are by no means either equal or synchronous. Over 75 per cent of the total increase of the brain-case has taken place by the seventh year, and nearly all of it by the fourteenth year, after which it continues to grow slowly until about the twentieth year. There are thus two periods of progressive decrease in brain-case growth velocity. During the first the face, which, steadily growing coincident with the eruption of the permanent teeth, grows relatively faster and gains upon the brain-case, while the facial changes associated with puberty cause it to catch up still further throughout the remainder of the second decade, this latter change being more marked in males. Brash's statement is based on measurements from widely diverse sources. In the growth of the face itself, the chief change is in the proportion of the length to the breadth, so that the facial index, which expresses length as a percentage of breadth, rises from 86 per cent at the sixth year to 90.6 per cent in the adult.

Next for consideration in the lateral skiagram and of great importance is the calvarial contour.

Apart from the variations in its shape, dependent upon the cephalic index of the individual, which most visibly affects the occipital part where dolichocephaly is most clearly seen, the contour is so influenced by age and sex that its form may greatly help to throw light on these facts when they have not been made available. Before the age of puberty there is apt to be little difference with sex. Anteriorly, in childhood the contour rises almost vertically, and in certain cases may even seem to overhang slightly, owing to the dominating prominence of the frontal eminences in the earlier years, when the glabella and the superciliary regions are as yet unmarked, and when the upper orbital margin is seen as sharp, while at the nasion there is a well marked incisura.

In childhood the curve of the squama

of the frontal bone, from the vertical to the more or less horizontal direction, is well rounded and somewhat more obtuse than a right-angle and reaches to about the bregma, the remainder of the vault being somewhat flattened as it rises to the vertex. With growth, and especially after adolescence in males, a profound change takes place in this anterior part of the contour, as part of a complicated adjustment incidental to associated changes in the masticatory part of the face. According to Tracy (32), the contour changes are chiefly in the forehead and in the occipital bone, behind the foramen magnum. She showed that the parietal bone in the child grows forward till about the tenth year, when no further forward growth takes place at the coronal suture. Thereafter, the direction of growth in the parietal bone is backward, while the frontal bone tilts, so that what was once the most prominent part of the forehead becomes less prominent than the glabella.

Keith and Campion (33), concluded that this tilting or rotatory movement of the frontal bone as a whole is produced by growth changes in the coronal suture, new bone being laid down in the suture margin above, while below, under cover of the temporalis muscle, resorption occurs and the parietal edge of the suture moves forward. Any failure of growth—or overgrowth—in any of the component parts of the base of the skull cannot occur without affecting profoundly the calvarial contour, and producing a definite degree of cranial dysplasia, of which the calvarial change is usually the most apparent expression.

In the post-pubertal period there is also a gain in vertical height of the brain-case, measured above the porion, which is more marked in males and helps to distinguish male from female crania. The female usually retains something of the flat quality of childhood in the vault contour as well as in the brow outline. A similar difference is found in the occipital part of the calvarial contour, where in the adolescent male growth produces a

come apparent, and all these data, simultaneously acquired, train the eye progressively in their integration, and lay the basis for a judgment that is much more surely founded than a vague clinical impressionism

It was to be anticipated that the estimate of the degree of differential growth or development would be more informative than that of mere dimensional growth. Todd and Schweikher (29), have defined development in the skull as "differential-time-growth, invoking time as a fourth dimension, its characteristic being the adjustment implied by adjacent areas undergoing growth of different velocities." That different component parts of the cranium and especially of the face, have different periods of active growth and different growth velocities is a fact that has long been recognized. A knowledge of the "time-tied" characteristics of the different cranial components is of the greatest importance in assessing the degree, not only of dimensional but especially of developmental growth in a skull at any given age, for it must be kept in mind that the two may not be synchronously active, and that differential growth may be most marked, normally, when general dimensional growth is least, an example of which are those facial changes which occur in the male face in late adolescence.

The great practical value of this "time-tied" quality of cranial growth, to the clinician, lies in the fact that should there occur during growth, for any reason, a period of transitory over-activity, of greater or lesser length, the structures normally growing actively during such period will be the most affected, and mal-adjustment may occur with adjacent structures, whose growth at the time is less active. This local overgrowth and the mal-adjustment it produces will remain throughout life as a record, not only of the degree of the growth disturbance, but of the time at which it took place.

The converse also is true, as Todd (30) points out in connection with the failure of thyroxin feeding to make good the cra-

nial defects produced by thyroidectomy in the growing sheep. "The date having passed for certain features of developmental growth without their appearance, these particular expressions are eliminated from the growth pattern—the missing details are lost for good." Apart from the "elimination" of certain features of cranial development, which results from thyroidectomy and more especially from hypophysectomy, there are many factors which may, temporarily or permanently, alter the differential growth pattern of the skull.

The Lateral Skiagram—The size of the skull, and the size of the face relative to the brain-case, are best appreciated from lateral skiagrams. Since these were taken routinely on a standard size film, an approximate idea of size could be secured from the area covered by the lateral projection, age and sex being taken into consideration. This impression of size can be better judged when 8 X 10 in films are routinely used rather than larger films, as the outline is nearer the margins of the film. When two crania are of equal circumference the lateral projection of the dolichocephalic will give an impression of larger size than in the brachycephalic, but whether a deduction or addition should be made in judging the size can be seen by reference to the postero-anterior projection, indicating to which type a skull belongs. Clearly this impression of size is of value in only extreme cases when it may be obvious that a given head is undoubtedly "large" or "small."

Of greater value, in the lateral view, is the impression of proportionate size between brain-case and face, the line of division being from the external auditory meatus to the supra-orbital fossa. This proportion is dependent on age, sex, and the degree of development and condition of the dentition. According to Brash (31), in the adult the face represents about one-half of the bulk of the whole skull, whereas at birth it is about an eighth. From birth to adult size the brain-case increases in size about four times, while the

skigram a datum of judgment of the greatest value. It has to be kept in mind, however, that distortion is inevitably present in the skigram, an important factor in this being the distance of the vault from the film, for which reason we now prefer for the lateral skigram the use of the Lysholm grid, which means the interposition of a thickness of only 5 mm between the head and the cassette.

An example of the actual degree of distortion found in the skigram of a calvaria, taken with the standard technic used in this laboratory, may be cited here, the abnormal specimen shown in Figure 10 (Part I) being used. The film lay in the cassette 4 mm beneath the tube-side surface. Above the cassette was a Lysholm grid 5 mm thick, and above this was supported the calvaria in true lateral position, and just clearing the grid. The anode-film distance was 30 in., the tube being centered over the estimated position of the sella turcica.

The calvaria had previously been marked with pencil at eight corresponding sites on both the outer and inner tables (Table I), and at these, small pieces of fine lead

a precision slide micrometer, while another independently measured with an anvil micrometer the exact thickness of the skull at the pencil marks (Table I). Thus we made it a practice to consider the possibility of a distortion of roughly 10 per cent. That a calvaria actually 5 mm thick should be made to appear even 6 mm, is not a serious matter.

Beadles (22), who worked with necropsy material and whose measurements were consequently made at the saw cut and not in the sagittal plane along the vault, accepted as normal calvarial thicknesses varying "roughly" from an eighth to a quarter of an inch, but where he did not indicate except at the parietal eminences, where thicknesses of from two to three sixteenths of an inch were regarded as normal. He held the male cranium to be somewhat thicker than the female and believed that there is a tendency to increasing thickness with age. From his autopsy measurements and those of three other authors—in all, well over two thousand cases—he concluded that in the insane there was a much greater want of symmetry of outline in the cranium and a much greater variation in thickness than in the sane.

Keith (21), took the normal calvarial thickness to vary from 5 to 7 millimeters. Todd (37), from 448 male white crania accurately measured, gives the following averages for adults: glabellar area, 11.3 mm, vertex, 5.9 mm, euryon (parietal eminence), 3.6 mm, opisthion (posterior margin of foramen magnum), 5.7 mm. He found that the cranial thickness does increase slightly with age, up to sixty years, but thereafter there is no real evidence of any normal change. He found no evidence to support the old view that the skull becomes lighter with age. He did find, however, evidence of "sporadic thickening of the cranium" after fifty, and also evidence that the frontal sinuses, which enter into his glabellar measurement and show extreme individual variability, do not appreciably increase in size during adult life. He found that skull thickness was of the same high order of variability as

TABLE I

1	Glabella	16.25 mm	16.5 mm	1.5 % plus
2	$\frac{1}{2}$ Glabella-bregma.	12.05	12	0.4 % less
3	$\frac{2}{3}$ Glabella-bregma	10.90	11.0	0.9 % plus
4	Bregma	9.8	10.0	2.04 % plus
5	$\frac{1}{4}$ Bregma-lambda	10.2	10.5	2.94 % plus
6	$\frac{1}{2}$ Bregma-lambda	12.0	12.0	
7	$\frac{3}{4}$ Bregma-lambda	11.45	11.50	0.43 % plus
8	Lambda*	11.8	12.5	5.9 % plus

* The greater distortion at the lambda is possibly due to the centering of the tube over the sella, i.e., forward of the center of the calvaria.

wire had been closely applied to the bone in the median sagittal plane, thus delimiting in the skigram the actual thickness of the cranium at the eight sites.

One observer measured on the film the intervals between the inner limits of the shadows of the eight pairs of wire fragments, reading to a tenth of a millimeter on

greater bulging behind the foramen magnum, the fossæ surrounding the cruciate eminence becoming more deeply convex outward, the sagittal sulcus deeper, and the internal occipital crest and protuberance more prominent. In the occipital contour, however, the external changes associated with the passage from youth to manhood are more easily seen, and coincide with the final cessation of brain growth. There is marked growth of the nuchal muscles, so that the prominent occiput of boyhood disappears, the curved lines become more prominent, and the external occipital protuberance and the mastoid processes become considerably better developed. In the female these changes are less well marked as a rule.

In acromegaly this natural transition may be carried to an extreme degree, the external protuberance and the curved lines being not only greatly increased by deposit of new bone, but even being carried upward and backward on the occipital squama as much as from 8 to 10 millimeters. This movement may even change the direction of the superior curved line, making it more oblique to the horizontal plane of the skull. The degree of this backward movement can sometimes be brought out by comparing the level of the external protuberance with the internal. Ordinarily, they are practically opposite each other on their respective surfaces of the bone, whereas in marked increase of nuchal attachment the external protuberance may be observed distinctly to be more highly placed than the internal.

The occipital contour is profoundly altered in certain dysplastic conditions. It is here that there occurs the chief cranial lesion in achondroplasia. According to Keith (34), the cartilaginous part of the occipital bone in the achondroplastic is not only small at birth, but reaches maturity precociously. Thus the part of the squama above the curved lines, which alone is developed in membrane, comes to form the major part of the squama, and since the cartilaginous part fails to grow and becomes too small to accommo-

date a cerebellum of normal size, the growing contents may push up the tentorial attachment till it comes to lie at the lambda.

Also in acrocephalic crania there is shortening of the posterior fossa of the skull, with distortion of the occipital contour, together with a similar deformity of the anterior fossa, due to an arrest of growth at the spheno-ethmoidal junction. Compensatory growth upward results in "tower skull." Keith (34), describes two variations of this condition—"frontocephaly," in which the posterior fossa is small and the anterior large, compensatory growth having gone frontalward, and "opisthocephaly," in which the posterior fossa is large and the anterior small, so that compensatory growth produces height at the vertex and an effect of marked prognathism. He points out that such dysplasias in the cranium are part of a general dystrophy affecting the whole body and suspects an endocrine etiology. Premature sutural synostosis is also a feature in these conditions, in which connection it is interesting to note that Bolk (35) suggests the possibility of very early closure of the sagittal suture being the cause of the condition known as "scaphocephaly."

Finally, the occipital contour, like the rest of the calvarial contour, may remain infantile and undifferentiated, as is seen in crania in progeria (36), cretinism, and dwarfism of pituitary origin.

Thickness and Structure of the Calvaria—In conjunction with the study of the calvarial contour, in the lateral skiagram, the thickness of the cranium in its different parts and its architectural structure—the first in large measure depending on the second—require consideration. Despite the facts that cranial thickness is known to vary markedly, not only between crania but in different parts of the same cranium, that there are also variations with age and sex, and that authoritative figures for average thickness at specific sites are by no means abundant, we have found the impression of cranial thickness and structure derived from the lateral

mode of growth in bone, a view with which Hunter disagreed

Such diploic expansion in marked degree, with increased vascularity, is a characteristic early change in acromegaly, and in a previous paper (28a) one of us (H M) showed that, in the white rat, the operation of hypophysectomy in the young animal is rapidly followed by disappearance, in the skiagram, of the diploic table from a considerable portion of the calvaria, and that this can rapidly be restored by the administration of a purified somatotrophic hormone from the anterior hypophysis. From the point of view of estimating the present or past growth activity in any calvaria, we have found the amount of diploe, seen in the skiagram, relative to the thickness of the other two tables to be a guide of the first importance.

The presence of diploe as a rule cannot be detected in the lateral skiagram until about the second year of life, when the increasing differentiation of the other two tables leaves a fine radioparent zone between them. With the rapid growth of the skull in the early years of childhood, the degree of calcification in the other two tables remaining low, the relative amount of diploe increases and it forms a considerable part of the total thickness of the bone. This fact is of considerable practical importance, for when the diploic table is poorly developed, either from aplasia of its own constituent structure, or when it suffers secondarily from obliteration by pressure from within the skull, the outer and inner tables come to lie closer to each other over the convexities of the cerebral convolutions, thus producing in the skiagram the appearance known as "convolutional impressions" or "convolutional atrophy." These by their presence may indicate increased intracranial pressure, in which case in the young there will usually be spreading of sutures, or mere absence of vigorous growth in the calvarial bones, which may or may not be significant. The condition may be seen in a number of young crania in which it means no more than that the skull is thin.

The changes in the diploe of the frontal bone are of special importance since not only are they greater in amount than elsewhere in the calvaria but it would appear that the progress of both normal and abnormal growth finds in it a more immediate and permanent expression. The reason for this may possibly lie in a relatively more unstable growth pattern produced by a train of both phylogenetic and ontogenetic circumstances. In man it has had to adjust to a very recent and a much more extensive increase in frontal pole neopallium than in any other primate, and the time necessary for this new pattern, acquired in evolution, to become fixed may not yet have elapsed. Superimposed upon this potential weakness are the prolonged and complex adjustments necessary to meet the needs of a brain that grows early and rapidly, and of a masticatory apparatus that grows in one sense even more vigorously but non-synchronously with the brain.

During the period of lagging dimensional growth of the brain-case, that goes on from puberty, it has progressively to consolidate its structure to final adult form, the achievement of which is signalled by the first spurt of suture closure. Structurally this consolidation consists of the building up of adequate inner and outer tables on the framework of the middle, after which an adequate diploic remainder fulfills the permanent circulatory vascular and hematopoietic functions. Throughout the whole of its growth and differentiation and thereafter all three tables are plastic. All reflect the level of general calcium metabolism in so far as the reserve may be increased or diminished, and in this sense may be used as an index. The middle table, in addition, may show trabecular resorption as a result of hematopoiesis, a fact that must be borne in mind, especially in children, when it is important not to mistake for evidences of overgrowth what is a reaction to an anemia. At adolescence girls are usually ahead of boys in differentiating and consolidating the calvarial bones, but in them the bone is normally somewhat

he had demonstrated in scalp thickness (38), from which he concluded that "it could not be under specific natural control as many dimensions seem to be" Krause (39), in 1879, gave the thickness of the external occipital protuberance as about 15 mm, but this, depending as it so largely does on muscular action, is extremely variable and not of great significance with reference to the thickness of the rest of the calvaria

In the lateral skiagram the adult calvaria is thickest in front just above the frontal sinuses, and from this point it gradually tapers off progressively to the coronal suture. It is common to note a slight diminution in thickness, appearing almost like a local buckling of the inner table, at the curve of the brow where the direction passes from vertical to horizontal. The thickness is somewhat less at the coronal suture and continues so in the anterior part of the parietal bone, again increasing toward the vertex and especially as the lambdoid suture is reached. Here the eye is apt to be deceived as to the thickness by the super-imposition of shadows produced by varying degrees of curvature in the flatter occipital part, especially if there is marked asymmetry in this region. The variation in thickness, as the calvarial contour is followed backward, is characteristic, and absence of this variation, as when the whole contour appears to have the same regular thickness, usually connotes a pathological change.

Structurally, the three tables of the normal calvaria are usually clearly distinguishable as far back as the union or even somewhat beyond. For the greater part they appear as three zones markedly differentiated in density, the inner table being highly radiopaque compared with the outer table, which in turn is considerably denser than the diploe, the red-marrow filled cancellous tissue which is comparable to the medullary cavity of a long bone. It contains the vascular return bed, the large diploic veins lying in channels in the cancellous bone with irregular pouch-like dilatations, both of which can sometimes be

seen in skiagrams of very vascular, somewhat poorly calcified crania, found mostly in youth and characterized by a relative increase in diploe. Before closure of the sutures they are confined to the bones they drain, but after union, when the sutures are "obliterated" they anastomose with those in adjacent bones and increase in size, except in the case of the occipital group which are confined to that bone (40). Their pouch-like dilatations can sometimes be seen like lacunæ in the diploe of the frontal and parietal bones, and when large may be mistaken for local pathological conditions.

The blood supply of the outer table is from the vessels in the deep layer of the periosteum, that of the inner from those in the endosteal layer of the dura. Growth in the bones of the vault, as in all cranial bones, is much more a matter of surface resorption and deposition than of addition at suture lines, as was clearly proved by the evidence found in the frontal and parietal bones of pigs fed with madder in early growth by Brash (31), a fact which, as that author points out, had been presumed by Senff, in 1801, when he applied the principles of bone growth enunciated by Hunter to explain growth in the flat cranial bones and the development of the frontal and sphenoid sinuses.

During active growth in bone it is axiomatic that wherever there is activity there is found a high degree of vascularity, there is decalcification around existing vascular channels so that these are opened up and cellular activity is increased. The effect of this in calvarial bones is absolutely, and for a time also relatively, to increase the amount of diploe, and by the process of resorption-deposition to enlarge or "expand" the intertrabecular spaces, so that one is justified, for convenience of description of a diploe which has passed through this process in a marked degree, to use the term "diploic expansion," it being clearly understood that the term does not mean that type of "interstitial expansion" of bone which Duhamel in the eighteenth century held to be the basic

tween the adjacent bones, which are still poorly calcified

At this time, the radioparent zone between the adjacent bones is relatively at its widest, the degree of calcification at the margins of the bones being somewhat less than elsewhere in them. Serrations and denticulations are at first not apparent at the coronal, and only poorly defined in the lambdoidal, suture. The increasing calcification that comes with growth increases definition, particularly in the lambdoidal whose deep denticulations become very prominent, especially at the lateral angles of the occipital bone, where they provide a marked contrast with the much less serrated occipito-mastoid suture. A fact that contributes to the clear definition of the lambdoidal suture lies in the bevelling of the inner table of the occipital and outer table of the parietal, bringing the axis of the suture from inner to outer table almost parallel to the path of the rays.

The coronal suture, except in the *pars bregmatica*, is not so easily seen. The part of it close to the median sagittal plane, due to bevelling of the inner table of the frontal bone and of the outer table of the parietal bones, appears as an obliquely placed radioparent zone running backward and upward from inner to outer table. Some serrations are visible in the upper part of the *pars complicata*, but lower down, owing to the marked bevelling of the outer table of the frontal and inner table of the parietals, and to the fact that in this site the bones are naturally thinner and hence relatively over-penetrated, the definition of the suture in most skiagrams is poor. In the second decade, evidence of changes preparatory to suture closure are often seen in the upper part of the suture—a tortuous area of increased density indicating the serrations. This to the casual observer may indicate closure, but careful inspection preferably of stereoscopic skiagrams, will show that the suture is still visible as a fine radioparent line in the denser area.

It is not possible in the skiagram to dis-

tinguish between closure of ectocranial and endocranial sutures, and this is not a matter of importance since, according to Todd and Lyon, on whose exhaustive study of endocranial and ectocranial suture closure we rely for our standards in this question (41, 42), found that closure in general makes itself evident on both aspects of the skull at one and the same date. They point out that the belief that endocranial closure precedes ectocranial is without real foundation. They found there was an orderly sequence in the progress of suture closure and that sex, race, cephalic index, and cranial capacity affect this age sequence only in minor degree or not at all. The sequence is sagittal, coronal, and lambdoidal, and the years from 26 to 30 form the period of election for both ectocranial and endocranial closure but that time-linkage is more obvious in the progress of endocranial union.

The first suture to close in the human cranium is the metopic, union in which coincides with the time at which the different parts of the occipital unite with each other, *i.e.*, about the fourth year. The significance of this is apparent.

Next, about the eighteenth to twentieth year the synchondroses of the cranial base—notably the spheno-occipital or basal suture—close. Bolk takes this closure of the latter as the criterion of the “adult” condition of any individual skull. This is quickly followed by the onset of closure of the most primitive part of the vault.

The Sagittal Suture—Todd and Lyon, in studying closure in this suture, divide it into four parts. They found that the first closure occurs on the outside of the skull in the *pars obelica* (the part associated with the parietal foramina), situated between the *pars lambdica* and *pars verticis*, at the age of 20, closure on the inner aspect of this part following about a year later, by which time closure has also begun on the outer aspects of the *pars lambdica* and *pars verticis*. By the end of the twenty-third year it has spread to the inner aspect of all the other parts of the suture, while at the outer aspect of the *pars bregmatica* there

less thick and there is a somewhat earlier acquisition of a dense inner table. Especially throughout the latter part of the second decade the male calvaria continues to grow and differentiate.

As the inner table becomes fully grown attachments of the falx are better seen and add apparent thickness to the inner table, especially in front at the frontal crest. Also the meningeal grooves become more apparent. If, however, the calcifying process is excessive, it may extensively invade the attached border of the falx on the one hand, or the diploe may become impregnated with calcium, producing a condition of sclerosis of the calvaria. This is more frequent in women and increases with advancing years. Thus the appearance and thickness of diploe in the skiagram largely depends on the degree of calcification of the inner table. The converse also is true.

We have observed, for instance, during the adolescent years when remodelling is taking place actively in the glabellar region, with resorption of trabeculae occurring ahead of the advancing frontal sinus, that the diploe just above the sinus is not only increased in amount, thickening the bone, but that its structure appears finely cancellous or "lava-like," the upper part of the bone being inadequately differentiated. This would appear to be entirely normal. It is not uncommon, however, at this age, especially in overgrowing adolescents, to find the greater part of the calvaria showing this lava-like diploe. In such cases the inner table is usually thin and poorly calcified, so that on the more lateral portions of the frontal and parietal bones, this lava-like diploe registers through the inner table and gives to the bone a mottled appearance. In such a skiagram the inner table is only a fine opaque line, the outer table is scarcely visible, and the cranium seems almost homogeneous in structure—throughout its thickness—which thickness seems constant in all the calvarial bones. Such a skull, even at a very early age, never shows convolutional markings, the diploic veins

are not visible, although the meningeal grooves may be faintly apparent. While its dimensional growth is excessive it is obvious that such a calvaria is poorly differentiated. That such diploe is very vascular and active in growth is almost certain, but although the possibility does arise that it may subsequently undergo normal differentiation, we are for the present inclined to regard it as a permanent hyperplastic manifestation because of its great structural similarity—in fact, apparent identity—to that found in Type 1 acromegaly, and because we have found it persisting in late life in crania showing other evidences of a past stage of hyperpituitarism. Whether it may occur as a transient stage, in growth, subsequently undergoing differentiation to normal structure, can be settled only by following such a case in a series of skiagrams, from the time of first recognition to well into adult life. We feel that we are further justified in regarding crania presenting such hyperplastic diploe as abnormal by the fact that it is in this type of young calvaria that we have observed those cases of premature synostosis of the coronal suture which we shall presently discuss.

Condition of the Vault Sutures—It would appear that there is some relationship between the closure of the vault sutures and the shape of the cranium although this may be very slight under normal conditions of growth. We have already referred to premature closure of the sagittal suture as a suggested explanation of certain cases of scaphocephaly as an example of this relationship.

In the lateral skiagram the coronal and lambdoidal sutures are usually visible, especially in young crania, although the details of the sagittal suture are lost in this projection, the last, however, in the young, can usually be made out in the postero-anterior view, as can also the metopic suture before the age of eight and later in those cases in which it remains permanently.

In infancy, the sutures are as a rule easily visible as radioparent zones be-

data, together with the clinical picture, could best be explained on the "assumption of the possibility" of a pituitary factor. In this group were certain cases in which it had been felt that the study had been insufficient, for one reason or another, and further studies had been suggested but had not been done. It should, however, be realized that such an opinion is arrived at neither lightly nor on evidence which would not compare well with such as is frequently offered as the basis of sound clinical opinion in consulting practice. The significance of such "possibility" is enhanced when it is recalled that in all cases this caption had been applied prior to, and independently of, the recognition of the cranial dysplasia, which could justifiably be regarded as a further link in an admittedly incomplete chain of clinical evidence.

The 70 cases under the caption "Lesion of the Central Nervous System" are of great interest. They include no cases of pituitary tumor, but do comprise cases referred as suspected endocrinopathies, in which the abnormalities in the physiologic findings have not been considered from the standpoint of endocrine diagnosis owing to discovery in the routine neurologic examination of symptoms indicative of damage to the cranial contents, either by trauma or disease. In this category were a significant number of cases of accidental trauma, sometimes of long standing, birth trauma, both from difficult labor and forceps injuries, and cases of definite or suspected extra-sellar neoplasm. In view of the suspected complicity of certain extra-sellar conditions in the production of certain clinical "pituitary" syndromes, we feel it justifiable to include in this group, for purpose of etiologic consideration, these 70 cases.

Finally, there were 16 female cases in which there was definite evidence of disturbed pituitary function in the past, but, since they had undergone castration for local disease of the ovaries, had been justifiably classed, for reference purposes, as "ovarian failure."

If we group together the cases bearing diagnoses under these three headings, for the reason that they either have, or may reasonably be presumed to have, a common pituitary factor in their ultimate etiology, we find that we thereby account for 74.3 per cent of those cases which, from their differential or developmental cranial growth and structural architecture, we have found to be dysplastic.

Of the remainder, thyroid disability accounts for only 6.9 per cent (34 cases) and 18.8 per cent (93 cases) belong to a group in which at the time of study, no abnormal endocrine condition could be found. But it should be noted that this fact does not preclude the possibility of endocrine disability in the past, which, although it may have left stigmata in the cranial structure as part of the growth record, may have been recovered from, the cranial deformity remaining, while the level of physiologic function became normal.

That cranial dysplasia can serve as a criterion by which to group cases with some common etiologic background which differentiates them from the average run of patients in an institution where the population is admittedly special (in that some 60 per cent are endocrine cases), can be seen from Table III.

TABLE III—CRANIAL DYSPLASIA
ETIOLOGIC COMPARISON

Diagnosis	Series	
	Control	X ray
Number	4,000	494*
Pituitary	30 0%	56 9%
Lesions of central nervous system	5 2%	14 2%
Ovary	11 7%	3 2%
Total	47 5%	74 3%
Thyroid	14 6%	6 9%
Non endocrine	35 0%†	18 8%

* From series of 2,950 cases

† Additional endocrine cases were 1.9 per cent

Using the total cases recorded as control material with which to compare those showing cranial dysplasia, certain important facts become apparent. First, pituitary disabilities are nearly twice as frequent in the dysplastic group as in the control

is a lag until 26. The pars obelica is the first part to reach complete union on both sides at 29. Progress is slower in the other three parts on both aspects until the twenty-sixth year, when a spurt takes place lasting till 30, so that by 31 the inner aspect is practically completely closed, and complete at 35, while on the outer, with closure about three-quarters achieved, the subsequent tendency is toward failure of completion.

The Coronal Suture—In commencement and completion of closure this suture lags behind the sagittal, with, however, a marked similarity in course of its partes bregmatica and complicata with that of the partes lambdica, verticis, and bregmatica of the sagittal. In those two parts closure begins at 24 years on the inner aspect and at 26 on the outer. From 24 to 26 on the inner aspect the process is gradual, and from then to 29 the progress is marked on the inside as it is also on the outside, except in the complicated part, where it is slow. Closure is complete on the inside by 38, while on the outside lapsed union is the rule.

The Lambdoidal Suture—Both inside and outside the skull at this suture progress keeps pace very evenly. Both really begin at 26 and make sharp progress till about 31, when inhibition seems to occur, markedly affecting the outer table, where lapsed union is well marked. Final closure of the inner side is about 42. On the outside there is apt to be in both the partes lambdica and media an evanescent and spurious closure at the twenty-first year.

These authors emphasize the clearly marked effort at closure which appears in the early twenties, and which they called "spurious effort." They found that if a suture shows no effort at closure by 22 years, it will not start activity till 26. Those that so react, do show spurious effort, they consider are "ripe" to be caught in the last wave of union activity, which, as Stevenson (43) showed in the case of epiphyses, undergoes a marked decline in the early twenties.

In brief, it might be said that the series

of cranial skiagrams was studied in the light of the main categories of change noted in acromegaly, special attention being given to any apparent evidence of disturbance of dimensional, differential, or structural growth, which might suggest an acromegaloid tendency or the reverse.

Dysplastic Types Found—Out of a total of 2,950 cranial skiagrams examined, 494 (16.7 per cent) presented appearances which justified their being regarded as abnormal. When their identity was disclosed, their diagnoses from the physiologic examination being supplied, it was seen (Table II) that of them three-quarters

TABLE II—CRANIAL DYSPLASIA BASIC DIAGNOSES

Diagnosis			
Pituitary	$\left\{ \begin{array}{l} \text{established} \\ \text{'probable'} \\ \text{possible} \end{array} \right.$	$\left\{ \begin{array}{l} 185 \\ 47 \\ 49 \end{array} \right.$	
Lesions of the central nervous system		281	56.9%
Ovarian failure		70	
		16	
		86	17.4%
Thyroid failure		34	
Non-endocrine		93	
		127	25.7%

had suffered from conditions more or less directly attributable to disturbance of pituitary function. A fact of obvious significance was that 281 cases, or 56.9 per cent of all the dysplastic, had already and independently been diagnosed as of pituitary origin. The words "probable" and "possible" require explanation. The former means that, on summarizing the case after study, for the benefit of the referring physician, it had been pointed out that, in the absence of definitely ascertainable organic disease, the abnormalities in the objective physiologic data, derived from the patient, showed the probability of there being a pituitary origin, although there was lacking that degree of definition which would have justified an "establishment" of pituitary diagnosis. Similarly, "possible" means that the divergence from normality of the physiologic



Fig 17

Fig 17 Type 1, cranial dysplasia (E-2383) with true prognathism in a girl aged 15 Evans diagnosis pituitary dysfunction



Fig 18 A

Fig 18-A Type, 1, A cranial dysplasia Male aged 14 years (E-2762) Evans diagnosis pituitary dysfunction

although the sex-ratio of the population does not completely account for the difference in percentage occurrence. Apart from ovarian trouble, women are more often the subjects of endocrine disease than men. In acromegaly, however, in 1,319 cases, Atkinson (23), gives the males affected as forming 51 per cent of the total.

In the Type 1 change, which might almost be considered as a minor degree of Type 1 acromegalic change (subacromegalic), there is a definite preponderance in favor of the males. The characteristics of this type are, that in an adult the head is apt to be "large," while in a younger person it may be large only relative to the age of the patient. The face is always well grown and may even form something more than half of the mass of the total cranium. As in acromegaly, the overgrowth may affect either the upper, middle, or lower thirds of the face, or all three. Associated with this is an overdevelopment of certain or all of the paranasal sinuses, and frequently the mastoid air cells are similarly affected. Such findings often give a clue as to the date at which the hyperpituitarism was active.

In general, it may be said that there is hyper-pneumatization of the face. In

cases in which the whole masticatory apparatus has suffered, prognathism results, while, if the mandible is involved alone or is affected to a considerably greater degree than the maxilla, prognathism results. There is a generalized overgrowth of cancellous bone throughout the whole cranium and this is most clearly noticeable in the diploe of the frontal bone, which is excessive in amount and frequently has a finely porous or "lava-like" structure.

In young persons, in whom overgrowth takes place rapidly, the above picture may undergo modification in that the calvaria may be actually thinned out by the rapid growth of its contents. This we recognize as Type 1, A.

In this group we have 75 cases of 17 years of age and under, 42 males and 33 females, 22 of whom (11 males and 11 females) showed premature synostosis of the coronal suture. This could justifiably be considered as an atavistic reversion to the anthropoid type, entirely consistent with the general admittedly atavistic character of the acromegalic type of overgrowth, in which differentiation is seriously impaired.

Type 2 is characterized by the persistence of changes of the Type 1 order,



Fig 15

Fig 15 Type 1 cranial dysplasia Male aged 52 years, a subacromegalic type (E 2448) pituitary dysfunction



Fig 16

Fig 16 Type 1 cranial dysplasia (E 2448) An extreme example of hyperpneumatization of the face.

group Second, lesions of the central nervous system are nearly three times as frequent, and third, ovarian trouble is three times less frequent In short, these three groups, while accounting for nearly half of the general run of cases, represent practically three-quarters of the dysplastic group, and this difference is chiefly due to the relatively greater number of cranial dysplastics who suffer from pituitary conditions

A point which adds to the significance of these figures is that thyroid disability is less than half as frequent in the dysplastic as in the normal run of patients in this special hospital Furthermore, since the problem of the factors influencing and controlling head-form and growth are of great interest, not only to the endocrinologist but to the anthropologist, the comparative anatomist, and the orthodontist, we find a fact on which we wish to lay stress—that in a relatively large series of cranial dysplastias, derived from a larger number of cases, fully studied physiologically, the disturbance of cranial growth and structure is eight times more frequently associated with pituitary than with

thyroid disabilities, and, if we include those conditions which reasonably may be expected to act through, or to be associated with, a pituitary mechanism, then the frequency is almost eleven times greater

Types of Cranial Dysplasia—It was found that the dysplastic crania could be arranged into four main groups, two of those being associated with hyperfunction of the anterior lobe of the pituitary, and two with hypofunction (Table IV) Since

TABLE IV —CRANIAL DYSPLASIAS
OF PITUITARY ORIGIN

Type 1	Cancellous overgrowth producing	Hyperplastic diploe
		Hyperpneumatization of face
Type 2	Type 1 change plus secondary sclerosis	Prognathism
		(or Progeniasticism')
Type 3	Inadequate growth of cancellous bone leading to	Hypoplastic diploe
		Hypoplastic paranasal sinuses
Type 4	Type 3 failure plus secondary sclerosis	Hypoplastic face and jaws
		(Progeniasticism')

women form the larger portion of the population of such a special hospital the fact that twice as many female cases occur as male may lose some of its significance,



Fig 20

Fig 20 Type 3 cranial dysplasia Female aged 22 years (E 2960) Compared with E-2956 the cranium is more dense This might be considered as a transitional type Evans diagnosis pituitary dwarfism



Fig 21

Fig 21 Type 4 cranial dysplasia Female aged 18 years (E-2956) Patient claims she formerly weighed 600 pounds, present weight 400 pounds Note the frontal sclerosis Evans diagnosis hypopituitarism, with obesity

In taking Types 2 and 4 together, since both of these are characterized by sclerosis, we find that this condition is ten times more frequent in the female than in the male. Even when there are no exostoses, there results, as a rule, a well marked thickening of the calvaria and it is well to remember that Todd has shown that there would seem to be absent, in the determination of skull thickness, factors similar to those which tend to limit man in his other cranial dimensions. There are factors at work which limit man in his height, which would seem to be lacking in his girth. Clinically, in these patients, we find the two conditions in frequent association. Experimentally, one of us (28a) has shown that a similar calvarial sclerosis can be produced by such treatment as renders a hypophysectomized rat resistant to the ketogenic effect of certain anterior lobe extracts. We are inclined to the view that it is a failure in this direction, occurring spontaneously, which is an etiologic factor in the production of Type 4, cranial dysplasia.²

²Since this work was done it has become routine practice to use a step penetrometer when cranial skiagrams are taken, the radiograph of which on the same film serves not only as an aid to the objective judge

ment of relative densities in different parts of the skull, but also indirectly to indicate the technic used in making the skiagram, when this is not known.

This penetrometer consists of seven steps. The bottom step consists of two pieces of 99.24 + per cent pure rolled sheet aluminum (British Aluminium Company) 12 cm long by 2.5 mm broad and 5 mm thick. Between these two are two pieces of commercially pure electrolytic rolled copper 1 mm thick, the lower of these has the same length and width as the two aluminum strips between which it lies. The upper piece of copper has the same thickness and length as the lower but only half its breadth and so covers only one half of the step. The second aluminum step has the same thickness and width as the first but is 20 mm shorter and the succeeding five steps are each in turn 10 mm shorter than the preceding. The seven steps are bolted firmly together at the end.

Thus one longitudinal half of the penetrometer consists of eight strips of aluminum each 5 mm thick plus two strips of copper each 1 mm thick while the other longitudinal half is 1 mm of copper less thick.

By the combination of the two metals a penetrometer of convenient dimensions (42 mm high) is obtained which if made in aluminum alone, would have a maximum thickness of approximately 70 mm of aluminum—an impracticable thickness.

The approximate density in millimeters of aluminum of the less dense half of the scale runs from 25 mm by increments of 5 mm of aluminum to 55 mm, while in the denser half it ranges from 40 to approximately 70 mm aluminum, by increments of 5 mm.

The routine use of this penetrometer in the hospitals from which cases are drawn permits comparison not only of skiagrams of the same patient made at different times but also of films from different institutions. Although it can be used to give a relatively accurate measurement of density of a given structure in terms of



Fig 18-B Type 2, cranial dysplasia. Female, aged 42 years (E 2955). Evans diagnosis: hypopituitarism (obesity, weight 300 pounds).



Fig 19 Type 3 cranial dysplasia. Male, aged 39 years (E 2967). Shows girdle adiposity, has sparse pubic hair and a harsh, deep-pitched voice. He is married and it is stated has a son. Evans diagnosis: pituitary dwarfism.

modified in their final picture by a sclerosis which has occurred secondarily and which the clinical evidence shows is associated with the hypofunctional phase which is so apt to follow the period of hyperfunction. There are almost ten times as many females as males in this group.

Type 3 is characterized by failure in both growth and differentiation. As a consequence, the cranium remains largely infantile in type. The brain-case is small, with poorly differentiated calvaria in which the middle table, in the skiagram, can be made out only with difficulty. The face suffers even more than the brain-case. The brow retains the verticality of infancy in the female, while in the male, in moderate degrees, it resembles more the female in outline. The frontal sinuses are poorly developed and as a rule have not grown above the nasion. The face fails both in vertical and forward growth, so that the antra and the circumnasal part generally is markedly hypoplastic. The teeth are crowded and there is apt to be true progenicism. A similar appearance occurs in the hypo-

physectomized rat and the general characteristic is insufficiency of growth in cancellous bone. In the rat we have

TABLE V—SEX DISTRIBUTION

Type	Male	Female	Total
1	157	117	274
2*	13	117	130
3	10	9	19
4*	5	66	71
Totals	185	309	494
	37%	63%	

* Sclerosis a feature ten times more frequent in women.

been able to make good this defect and even to produce a relative hyperplasia by the exhibition of a purified somatotrophic hormone extracted from the anterior pituitary.

In Type 4 the hypoplasia is usually of a less degree than in Type 3 and the characteristic appearance is produced by well marked sclerosis of the bone. This is particularly well seen in the inner table of the frontal bone where large exostoses may be found even in relatively young persons. In our series it is more than twelve times more frequent in the female and, in the great majority of cases, it is associated with that type of hypopituitarism that results in well marked adiposity, which tends especially to have a girdle distribution.

* Careful distinction must be made between Type 3 Acromegalic Change (the third type of cranium found in the acromegalic material) and the clinical Type 3 Cranial Dysplasia. The former actually serves as the prototype of Type 4, Cranial Dysplasia. There was nothing in the acromegalic series corresponding to Type 3 Cranial Dysplasia.

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Fig 22

Fig 22 Type 4, cranial dysplasia Female aged 32 years (E 2803) Evans diagnosis pituitary dysfunction obesity



Fig 23

Fig 23 Type 4 cranial dysplasia Male aged 44 years (E 2478) Evans diagnosis pituitary dysfunction

In the 494 cases of cranial dysplasia found, 63 cases (12.7 per cent) presented history of an earlier diagnosis by a psychiatrist, in some other institution, of a psychotic or psychoneurotic condition. An additional 28 patients (5.6 per cent), all of whom were under 17, had previously shown such mental deficiency and "behavior problems" as to merit institutional treatment. Grouping these together, we find that 18.3 per cent of the cases of cranial dysplasia, three-quarters of which show dyspituitarism, by physiological investigation, also show in association with it a mental or emotional abnormality. We feel it would be unwise, in this regard, to

do more than present the percentage occurrence.

SUMMARY

(1) In a series of 2,950 cases, forming part of a series of 4,000 referred for endocrine study, there was found, from inspection of the cranial skiagram, 494 (16.7 per cent) that showed evidence of such disturbance of cranial growth and differentiation as to justify a diagnosis of dyspituitarism.

(2) Independent and previous physiological investigation gave evidence at the time of examination of disturbed pituitary function.

(3) In this percentage the present physiological status of the patients confirms the constitutional estimate derived from the cranial skiagram.

(4) Of this group, 18.3 per cent showing dyspituitarism and dysplastic crania, gave evidence not only of general bodily disturbance of growth and development, but also showed significant personality changes.

TABLE VI—THE RELATIONSHIP OF
"PERSONALITY" CHANGE TO CRANIAL
DYSPLASIA

Cranial dysplasia	494 cases	
Earlier psychotic and psychoneurotic episodes	63 cases	12.7%
Mental deficiency and 'behavior' difficulty	28 cases	5.6%
		18.3%

millimeters of aluminum its chief use is to give the examiner a rapid and accurate impression of the penetration employed in making the skiagram and hence of the true density of the skull.—H. M.

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(Reference numbers to this point accompany Part I)

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ured, we find the percentage of the measured dose caused by scattered radiation. For 1,000 kv this is 53 per cent, for 200 kv, 80 per cent. The doses at the level of exit, a depth of 23 cm, are 13.5 per cent and 6.5 per cent, respectively.

These curves demonstrate that for the 200 kv radiation, the depth dose in wax is much greater than it is in rice. The curve of the depth dose, using the field 10 by 10 cm in size, showed that the depth doses at 10 cm were wax, 40 per cent, rice, 36 per cent. Thus the depth dose in rice is 10 per cent less than that in wax. This agrees with the difference between the cadaver and wax as shown by Quimby (4). Thus rice more nearly approximates the cadaver as a medium of absorption than does wax. The greater depth dose in wax is explained partly on the basis of the fact that there is less photo-electric absorption of soft scattered radiation because of the relatively greater amount of hydrogen. The difference in depth doses between rice and wax, using 500 kv monochromatic equivalent radiation, was only a few per cent at 10 cm, because the scattered radiation, being still quite hard, depends for its absorption only on the electronic density—which is approximately the same for rice and wax. Thus wax can be used on the supervoltage apparatus for the measurement of depth doses with results fairly comparable to those made on a person.

The graphs for 200 and 1,000 kv depth doses in wax, as shown in Figure 2, cross each other at the level of 8.5 cm. Above this level there is a considerably greater depth dose for the lower voltage radiation. The absorption of 200 kv radiation in fat probably simulates that in paraffin more closely than that in rice. This would seem to indicate that, for small tumors embedded in fat, such as small tumors in large fatty breasts, treated tangentially, 200 kv radiation is superior to 1,000 kv radiation.

In Figure 3 are placed side by side the depth dose curves of the two kilovoltages in the rice phantom 23 cm in depth, for fields of three sizes. It is evident that the depth doses for fields of the same size are

greater in every instance for the supervoltage radiation, and that the ratio between the two is greatest at all depths for the field of smallest size. At depths of less than 7.5 cm the depth dose of the 200 kv radiation, using a field 20 by 20 cm in size, are slightly greater than those of the 1,000 kv radiation using a field 10 by 10 cm in size. The ratio between the depth doses of the two types of radiation at various levels increases as the depth increases and as the size of the field decreases.

From these various findings one can deduce that 500 kv monochromatic equivalent radiations will produce greater depth doses than 100 kv monochromatic equivalent radiations, as measured by ionization in a thimble chamber. The differences between the respective depth doses increase with increasing depth and with decreasing size of the field. The dose at the surface of exit is increased more, in proportion.

It is impossible ever to deliver a sufficient dose of radiation to a tumor, except one directly on the surface, through a single field. The application of the measurement of depth doses necessitates, therefore, determining what the resultant dose will be in the various regions when cross-firing is used. The fact must be recognized that the depth dose at a given level in a phantom of infinite thickness is not the same as the depth dose at the same level in a phantom of definite thickness. It has been found that a thickness of at least 10 cm phantom material is needed below the chamber at any particular depth to obtain practically complete back-scatter. If, for example, a phantom were only 12 cm thick, then at the depth of 6 cm, *i. e.*, the middle, there would not be sufficient material beyond to provide the same amount of back-scatter as would be present at a given depth in an infinite phantom. Hence the dose measured at a depth of 6 cm would be less in a phantom 12 cm thick than in a phantom of infinite thickness, and, as the field of exit was approached, the intensity would diminish more rapidly. True values of depth dosages in thin and variously shaped sections should be ob-

It is very evident from the curves (Fig 1) that the depth dose of the 1,000 kv radiation is greater than that of the 200 kv

is not so effective. It is also to be noted that the depth dose of the 200 kv radiation decreases much more rapidly, as greater

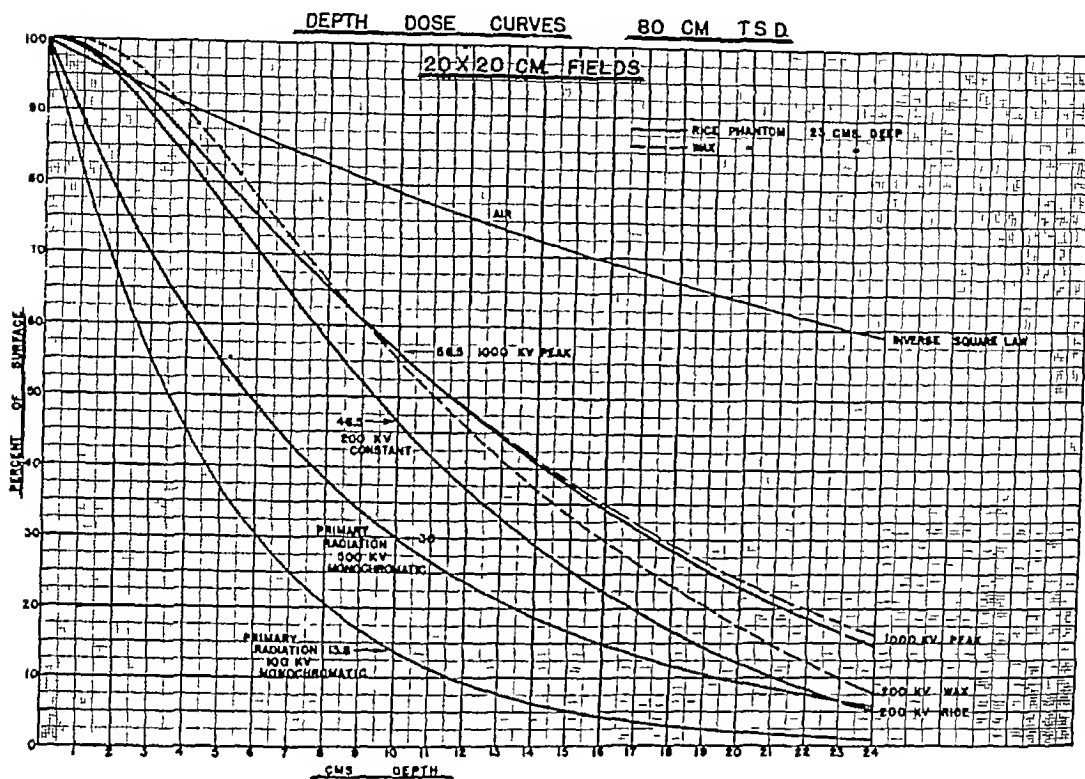


Fig 2

radiation at all levels below 15 cm, and that the percentage of difference increases as greater depths are reached. At a depth of 10 cm in the rice the percentages are 48.5 and 36, respectively, and the doses at a depth of 23 cm, the level of exit, are 12.5 and 4. This great difference can be explained by the fact that the percentage of the primary beam reaching the various levels is much greater in the case of the supervoltage than in that of the high voltage radiation. At a depth of 10 cm the primary radiation of the 1,000 kv beam is reduced to 30 per cent of its surface intensity, while that of the 200 kv beam is reduced to 13.8 per cent. The field being small, there is relatively little scattered radiation, and therefore the softer x-ray, depending on scattering for its depth dose,

depths and the surface of exit are reached, than does the depth dose of the 1,000 kv radiation. This has a bearing on the practical application, as will be shown later.

Figure 2 shows the curves of depth dose for fields 20 by 20 cm in size, the other factors remaining as before. These curves show very clearly that while the depth doses of the 1,000 kv radiation in rice, are greater at all levels below 1 cm than are those of the 200 kv radiations, the percentage of difference between the two is not nearly so great as it is when the smaller fields (10 by 10 cm) are used. At a depth of 10 cm the dose from the 1,000 kv beam is 56.5 per cent and that from the 200 kv is 46.5 per cent. For the 10 cm level by subtracting the depth dose as calculated for the primary beam from the depth dose as meas-

supervoltage diminishes. It is seen that, using a cross-fire technique through a region as thin as 12 cm, there is little if any gain in the depth dose obtainable by supervoltage roentgen therapy.

COMPARATIVE INFLUENCE OF EXIT SKIN DOSE USING HIGH AND SUPER VOLTAGE

CASE OF THICK SECTION 24 CM.

<u>10X10 FIELDS</u>						<u>20X20 FIELDS</u>						
<u>SINGLE-FIRE</u>			<u>CROSS-FIRE</u>			<u>SINGLE-FIRE</u>			<u>CROSS-FIRE</u>			
<u>200 KV</u>	100	27.5	3.2	103.2	55	103.2	100	37	55	103.5	74	106.5
				100	53.3	100				100	70.2	100
<u>1000 KV</u>	100	41	11	111	82	111	100	48	15	103	96	115
				100	73.9	100				100	83.8	100
<u>RATIO</u>	$\frac{1000 \text{ KV}}{200 \text{ KV}}$	$\frac{41}{27.5}$	$\frac{1.49}{3.2}$	$\frac{73.9}{53.3}$	$\frac{1.39}{55}$		$\frac{48}{37}$	$\frac{1.30}{55}$		$\frac{83.8}{70.2}$	$\frac{1.19}{74}$	

Fig 4

in the dose at the center relative to the doses at the surfaces even when using the field 10 by 10 cm in size. If portals smaller than 10 by 10 cm were used, the increased depth dose obtained with the use of 1,000 kv would be of more significance. For thicknesses above 12 cm it is seen that there is a definite and appreciable increase in the depth dose obtainable by the use of 1,000 kv, and that this is more noticeable for fields of the same size with thick patients and for patients of the same size using small fields.

The tabulation (Fig 5) shows the values for only two-field cross-fire irradiation. If more fields were added without any overlapping of the first two fields, the percentage of improvement would be still more marked.

The practical application of these facts to problems of treatment is somewhat obvious. If one were dealing with a thin

applied. If large fields must be irradiated the advantage of the supervoltage therapy is appreciable but not great. When the factor of the dose on the opposite skin can be diminished by the use of multiple small ports without excessive overlapping of the fields of entrance and exit, by avoiding direct cross-fire, or by irradiating thick parts, supervoltage is distinctly advantageous.

The depth dose measurements were obtained by placing the thimble chamber in the center of the fields. It was shown above (Fig 2) that at a depth of 10 cm in a phantom 23 cm thick and with a field 20 by 20 cm in size, 80 per cent of the measured dose of 200 kv radiation was due to scattered radiation and 20 per cent to the primary beam. In the case of the measured dose for 1,000 kv radiation under the same conditions, only 53 per cent was due to scattered radiation and 47 per cent to the

tained on phantoms of the desired size and shape. This is planned, but for the present, dosage measurements have been sections when using high voltage as compared to supervoltage than is shown by our calculations.

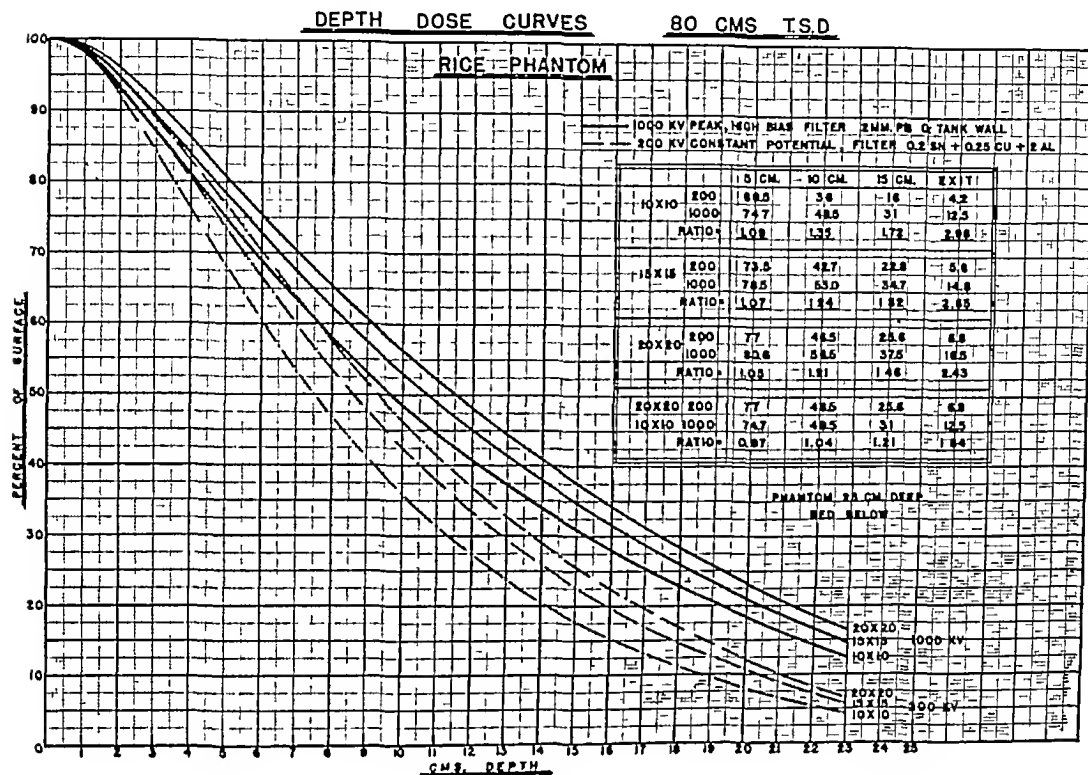


Fig 3

taken from the curves obtained with a phantom 23 cm thick. The cross-fire values recorded for the center of the thin sections will thus be a little in error. What we have used as the dose on the surface of exit is in reality the dose at the given depth in the phantom 23 cm in depth. This measurement would be smaller if it were actually on the surface of exit, because of the absence of back-scatter radiation. The dose at half this level (center of the thin phantom) would decrease less by decreasing the thickness of the phantom because some back-scatter radiation would remain.

Moreover, these doses being affected by the presence or absence of back-scatter will not vary in the same proportion with the two types of radiation. Consequently there is a possibility that there is a greater increase in the dose in the center of thin

Figure 4 is a schematic diagram comparing the relative intensities on the surface and at the center of a rice phantom 24 cm thick, using both single- and cross-fire methods with both high and supervoltage radiations. It is readily seen from the ratio of the doses at the center, produced by the supervoltage and high voltage radiations, that the increase caused by the supervoltage radiations is less for the cross-fire than for the single-fire method. It is also evident that with cross-fire, as well as with single-fire, the increase, using supervoltage radiation is greater for smaller fields. It is to be noticed that even with fields 20 by 20 cm in size, in the case of a thick region there is still an appreciable gain in the dose at the center. Considering progressively thinner phantoms, as shown in Figure 5, the percentage of gain by

is still largely composed of high energy photons. At the surface of a wax phantom, using a field 20 by 20 cm in size, 14 per cent back-scatter was measured. At a depth of 23 cm in wax the intensity was increased only 15 per cent by the back-scatter radiation from a large amount of wax added below the phantom. Hence, even after penetrating 23 cm of wax, the beam produces scarcely any more back-scatter than at the surface. Similar measurements with 200 kv radiation reveal 44 per cent increase due to back-scatter at the surface, and 67 per cent back-scatter after penetrating 23 cm of wax. The difference in quality within the phantom for the two radiations is of such magnitude that it should disclose any significant dependence of biological reaction upon the photon energy (wave length).

The question of a difference in the response of biological material to different types of radiation is difficult to settle. At this present writing only one phase of this subject will be considered, namely, the skin reaction. Lauritsen's curves show that approximately 525 r (air measure) with 100 kv monochromatic equivalent radiation should give the same skin reaction as 1,100 r (air measure) with 500 kv monochromatic equivalent radiation. Thus it should be possible to give approximately twice the number of roentgens measured in air with 1,000 kv radiation as with 200 kv radiation. This skin reaction is found when the energies are delivered at one sitting and at approximately the same rate. We have not satisfactorily tested these doses, but they are reported as having been checked.

Nearly all of our treatments have been given by the protracted, equally fractionated method, and by this method we find a much smaller difference between the amounts that can be given. Let us take the pelvis as an example. During the last few years we have treated our patients either with one field, 20 by 20 cm, in front and one in back, or two fields 10 by 15 cm, in front and two in back. We treat them at daily intervals, except Sunday, treating the anterior fields one day, and the posterior

fields the next day. The routine course is 20 treatments, 10 in front and 10 in back. Allowing for Sundays this takes from 22 to 25 days of elapsed time. The treatment factors were the same as described above for the phantom measurements. The dosage was measured by a Victoreen condenser r meter and the units are hereafter described as "equivalent r." When the 1,000 kv radiation was used for patients averaging 20 cm in thickness, a total dose per field of 2,500 r, in ten doses of 250 r, was given as described above. When using the 200 kv radiation, a total dose per field of 2,000 r, in ten doses of 200 r, was administered. In both instances the skin reaction was the same. The reaction occurred in both series in about twenty-eight days from the beginning of the treatment. Thus if we use the equivalent r measurement in air we have a ratio of 2,500 to 2,000. This is much less than the two to one ratio found for single threshold doses.

There are several possible explanations for this discrepancy: (1) in the protracted series, cross-fire is used and the dose on the skin at the place of exit is appreciably greater for the supervoltage radiation, (2) the recovery factor of the skin may be less for the harder radiation, (3) the skin reaction we observed is a marked erythema rather than a threshold pigmentation, (4) the roentgen as measured by the same thimble chamber may be different from the "theoretical roentgen" for the different radiations.

Another practical factor to be considered is that the limitation of the dosage which we can apply is not always the effect on the skin but is frequently the effect on the mucosa. With the supervoltage therapy one is able to deliver more to the depths of thick parts than with the ordinary high voltage therapy, but the normal tissue surrounding the neoplasm receives the same increased dosage. The amount of normal tissue irradiated will be less if small fields can be used to get the same dosage into the necessary region in the depths. By using a target-skin distance of 80 cm with the 200 kv apparatus it is possible to produce as

primary beam Since the primary beam spreads evenly, whereas the scattered radiation builds up in the center of the irradiated

Another fact emerges from these same considerations Since there is less scattering for the same depth dose, it follows

COMPARATIVE DEPTH DOSES 80 cm T S D									
CONDITIONS			SINGLE FIRE				CROSS FIRE		
RICE PHANTOM			ENTRANT	MIDLINE	EXIT	PERCENT	TOTAL	MIDLINE	PERCENT
THICKNESS	FIELD	KV	SURFACE	CENTER	SURFACE	INCREASE	SURFACE	CENTER	INCREASE
24 CM	10x10	200	100	27.5	3.2		100	53.3	
		1000	100	41	11	49	100	73.9	39
	15x15	200	100	33.5	4.5		100	64.1	
		1000	100	45.1	13	34	100	79.8	24
	20x20	200	100	37	5.5		100	70.9	
		1000	100	48.1	15	30	100	83.6	18
20 CM	10x10	200	100	36.0	8.0		100	66.6	
		1000	100	48.5	18.3	35	100	82.0	23
	15x15	200	100	42.7	10.8		100	77.1	
		1000	100	53.0	21.1	24	100	87.5	13
	20x20	200	100	46.5	12.2		100	83.0	
		1000	100	56.5	23.1	21	100	91.8	10
16 CM	10x10	200	100	47.0	15.5		100	81.3	
		1000	100	58.0	28.2	23	100	90.5	11
	15x15	200	100	53.8	19.8		100	90.0	
		1000	100	62.3	31.7	16	100	94.5	5
	20x20	200	100	57.7	22.5		100	94.3	
		1000	100	65.1	34.3	13	100	97.0	3
12 CM	10x10	200	100	60.5	27.5		100	95.0	
		1000	100	68.8	40.8	14	100	97.6	3
	15x15	200	100	66.6	33.5		100	100	
		1000	100	72.8	45.2	9	100	100	0
	20x20	200	100	70.5	37.0		100	103	
		1000	100	75.3	48.0	7	100	100	-1

Fig 5

mass, the dose at the sides of the beam of the 1,000 kv radiation as contrasted with that of the 200 kv should be more nearly the same as that at the center on the same level This was found to be so by measurement In other words, the isodose curves are flatter for 1,000 kv radiation and the dose is more evenly distributed This fact allows the use of smaller fields since the edges of the beam are not wasted or used only to build up scattering for the center

that there is less spread of the radiation into the tissues adjacent to the beam This is of value when considering the irradiation of closely approximated fields, or of lateral fields through a thin patient It must be remembered that the 1,000 kv radiation is different from the 200 kv radiation, not only in the distribution but also in the quality of the radiation within the phantom Since the scattering is mostly in the forward direction, the scattered radiation

FURTHER STUDIES ON THE RATE OF RECOVERY OF HUMAN SKIN FROM THE EFFECTS OF ROENTGEN- OR GAMMA-RAY IRRADIATION¹

By EDITH H. QUIMBY, M A, and W S. MACCOMB, M D,
Memorial Hospital, New York City

IN a previous communication, the authors have described a method for determining the amount of recovery in human skin after irradiation, and have presented data for a few specific schemes of treatment (1). This work has now been extended to cover the usual types of protracted and fractionated therapy. Data are here given which permit the computation of the approximate cumulative dose of radiation in the skin at any time during the treatment period. Studies have also been made of the effect of different fractionations of a certain dose delivered in a

of radiation which, delivered in equal fractions, with any specified intensity, produced the same skin reaction as the standard threshold dose. When it was found, for instance, that two doses of 400 r each (measured in air), with a 24-hour interval between them, produced the same reaction as 525 r at one sitting, the recuperation in the 24-hour interval was calculated as follows. Of the first 400 r, enough must remain apparently effective at the end of the interval to give, when added to the second 400 r, a total effect corresponding to 525 r. That is, 125 r of the first dose

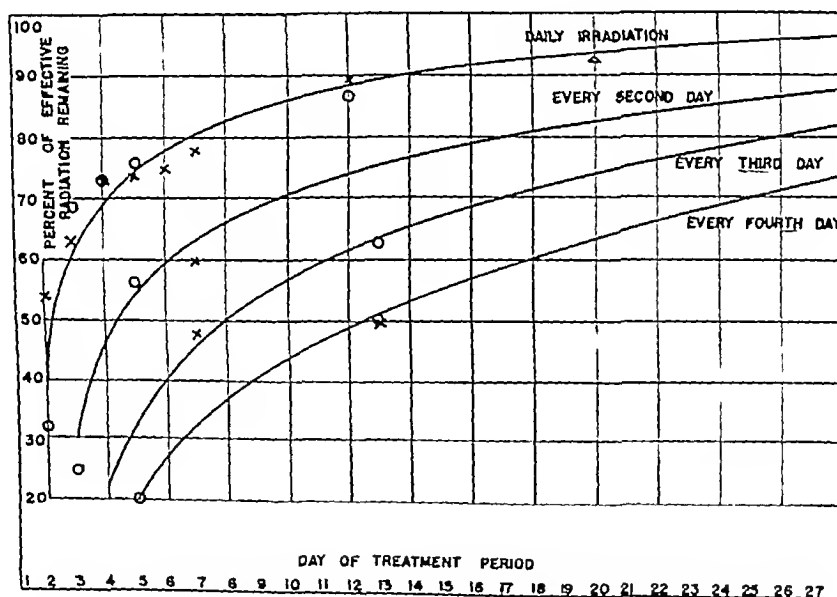


Fig 1 Curves showing percentage of cumulative dose remaining at any time during treatment period 200 kv x rays

specified period, and of the effect of varying the intensity of the radiation when a given total dose is delivered in a given time.

It will be recalled that the experimental work consisted in determining the amount

might be considered to remain effective, 275 r must have been recovered from. This implies a recovery factor for 24 hours of $\frac{275}{400}$, or 69 per cent.

It was emphasized that any such conception must be purely arbitrary. No actual amount of radiation or of ionization remains in the tissues. The effect that re-

¹ Presented before the Twenty second Annual Meeting of the Radiological Society of North America at Cincinnati Nov 30-Dec 4 1936

severe a diarrhea as one cares to produce, without causing any excessive changes in the skin. In such a case it would seem that the limiting factor is not only the dosage applied to the skin, even with the 200 kv apparatus, but is also the dosage applied to the mucosa of the intestinal tract.

When dealing with the thinner regions of the body such as the neck, the gain in depth dose, as was shown above, is offset by the corresponding increase in the dose to the skin in the region of the exit. Consequently it is not possible to get an appreciably greater depth dose to the tissues of the neck with the 1,000 kv than with the 200 kv radiation. This has been borne out in practice. We have found that, in order to produce similar mucosal changes in the pharynx, similar skin changes must be produced, whichever type of therapy is used.

We wish to express our thanks to Mr Milton A. Chaffee for his valuable assistance during the course of this work.

SUMMARY AND CONCLUSIONS

An attempt has been made to compare the radiations produced by 1,000 kv and 200 kv. The monochromatic equivalent kilovoltages of the beams used were 500 and 100, respectively. The comparison made by thimble chamber ionization measurements and by skin reactions, show, so far as such measurements are valid, that

(1) The supervoltage radiation delivers larger depth doses, the gain increasing with (a) the depth, (b) the decrease in the size of the field.

(2) In cross-fire technic the large doses on the surface of exit offset somewhat the practical value of the large depth doses. Supervoltage radiation can be used to greater advantage if (a) direct cross-fire can be avoided, (b) the parts treated are thick, (c) multiple small fields can be used without excessive overlapping on the opposite skin.

(3) The scattering of radiation into the tissues adjacent to the beam is less with supervoltage radiation.

(4) The isodose curves of supervoltage radiation are flatter.

(5) Using the protracted fractionated method of treatment, the total number of roentgens that can be given with 1,000 kv radiation is much smaller in proportion to the total number of roentgens that can be given with 200 kv radiation, than that calculated for single threshold skin doses.

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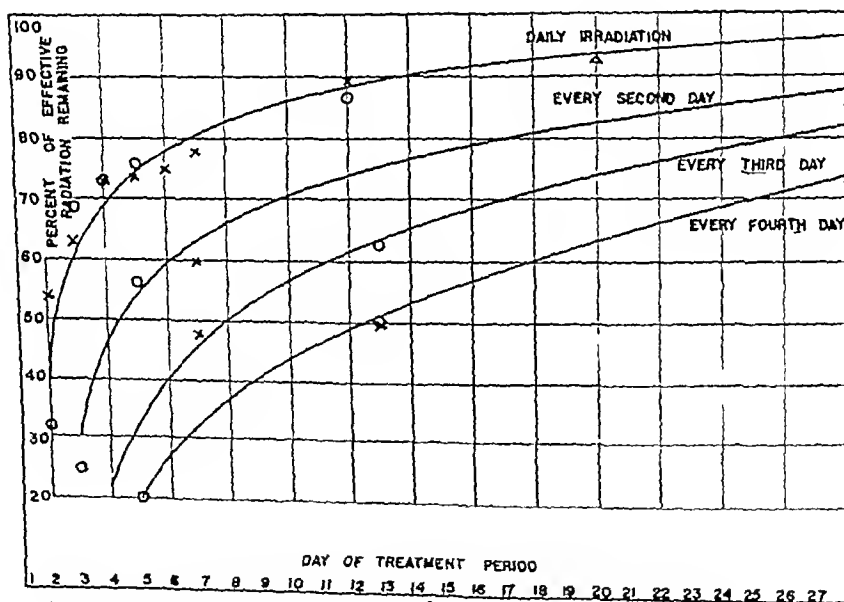


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TABLE I —IRRADIATION SCHEMES PRODUCING THE SAME SKIN REACTION

200 kv

0.5 mm Cu

0.5 mm Cu

A Two Equal Irradiations Different Intervals

Interval (Hours)	r per Irrad	Total r	Per Cent
6	320	640	122
12	350	700	133
24	400	800	152
48	425	850	162
96	440	880	168

B Equal Daily Irradiations Different Periods

Quinby and MacComb 70 sq cm				Reisner 4 sq cm			
No of Irrad	r per Irrad	Total r	Per Cent	No of Irrad	r per Irrad	Total r	Per Cent
1	525	525	100	1	1000	1000	100
2	400	800	152	2	650	1300	130
3	275	825	157	3	500	1500	150
4				4	400	1600	160
5	185	925	176	5			
7				7	300	2100	210
12	100	1200	228	12	200	2400	240
27				27	100	2700	270

C Additional Data for Longer Intervals

No of Irrad	Interval (Hours)	r per Irrad	Total r	Per Cent
4	96	300	1200	228

All quantities of radiation measured in air

mains is the consequence of the total ionization produced by the original irradiation. But it is evident that some recovery has taken place, and for purposes of dosage calculation, and of obtaining some idea of the effect of the interval on the cumulative dose, it is convenient to say that *the tissue acts as if a certain part of the radiation remains effective*. For three or more daily treatments, similar calculations can be carried out. For details the reader is referred to the first paper.

In Table I are given the available data for 200 kv x-rays. In addition to the authors' data, those of Reisner (2) for various numbers of daily irradiations are included. Practical applications of these data will now be developed.

A The Calculation of the Cumulative Dose—In the earlier paper it was shown that the recovery during the second day of

treatment was 31 per cent, or that 69 per cent of the cumulative dose remained effective when the third treatment was to be administered, and 24 hours after the third treatment, 74 per cent. Corresponding figures obtained from Reisner's data were 65 and 74. By carrying out similar calculations for data from longer treatment periods, the values have been obtained from which the curves of Figure 1 were plotted. Points obtained from the authors' data are indicated by circles, those from Reisner's by crosses.² A single additional point can be obtained from the data published by Low-Beer and Redisch (3) and is indicated by a triangle. The upper curve, which is

² It should be noted that Reisner has made no calculations of this sort. He has determined the various fractionated doses required to produce his standard reaction but has drawn no conclusions from them regarding recovery. The authors have simply applied their methods of calculation to his published data.

well covered experimentally, shows the percentage of the cumulative dose at any day of the treatment period, when daily irradiations are given. Its use is best illustrated by an example.

Example Calculate the daily cumulative dose when 300 r are administered to a given field daily for five days

First day—300 r administered η

Second day—45 per cent remains effective

$$0.45 \times 300 = 135$$

Add 300 r $300 + 135 = 435$ r effective

Third day—65 per cent remains effective

$$0.65 \times 435 = 280$$

Add 300 r $300 + 280 = 580$ r effective

Fourth day—71 per cent remains effective

$$0.71 \times 580 = 415$$

Add 300 r $300 + 415 = 715$ r effective

Fifth day—75 per cent remains effective

$$0.75 \times 715 = 535$$

Add 300 r $300 + 535 = 835$ r effective

That this is a reasonable value for the cumulative dose is demonstrated clinically by the fact that the skin reactions produced by a single dose of 825 r and by five daily doses of 300 r are about the same.

In order to find the accumulated dose at any time by means of these curves, it is necessary to go through the type of calculation indicated in these figures. It would be convenient if this could be avoided. For any definite scheme of irradiation, such calculations can be made once for all, and the results tabulated for ready reference. Table II provides these data, for 100 r administered daily, or every two, three, or four days, the accumulated dose, in "effective roentgens," at any day of the treatment period, may be read directly. For individual doses of any other magnitude the accumulated dose at any day will be in the same ratio to that in the table as the daily dose is to 100 r.

The lower curves of Figure 1, for irradiations every second, third, or fourth day, are not as well covered experimentally as the first, but there are enough points to indicate that they must be approximately correct. The work involved in verifying points on the curves is considerable, for each one requires tests on several patients

TABLE II—ACCUMULATION OF RADIATION DOSE IN SKIN DURING TREATMENT PERIOD

Day of Treatment	100 r Daily	100 r Every Second Day	100 r Every Third Day	100 r Every Fourth Day
	Accumulated Dose—Effective Roentgens			
1	100	100	100	100
2	140			
3	190	130		
4	235		125	
5	280	170		120
6	320			
7	360	205	160	
8	400			
9	440	240		150
10	480		190	
11	520	275		
12	565			
13	610	310	220	175
14	655			
15	700	340		
16	745		250	
17	790	370		205
18	835			
19	880	400	280	
20	930			
21	980	430		235
22	1025		315	
23	1070	465		
24	1115			
25	1165	500	350	265
26	1220			
27	1275	535		
28	1330		385	
29	1385	570		310
30	1440			
31	1500	605	425	
32	1555			
33	1610	645		360
34	1670		470	
35	1730	685		

It is evident that no serious error exists in this group of curves. Figures 2 and 3 show the day-by-day accumulation of dose, in special cases, calculated as above.

B The Effect of Varying the Fractionation of the Irradiation—From Figure 3 it is suggested that if the total dose and total treatment time are the same, within certain limits, the number of fractions into which the radiation is divided is not particularly important. This is borne out by a number of experimental observations which are summarized in Figure 4. Reisner has also observed this fact, in administering to one field 12 daily doses of 20 per cent each, and to another four doses of 60 per cent each, on

TABLE I—IRRADIATION SCHEMES PRODUCING THE SAME SKIN REACTION

200 kv

0.5 mm Cu

0.5 mm Cu

A Two Equal Irradiations, Different Intervals							
Interval (Hours)		r per Irrad		Total r		Per Cent	
6		320		640		122	
12		350		700		133	
24		400		800		152	
48		425		850		162	
96		440		880		168	

B Equal Daily Irradiations Different Periods							
Qumby and MacComb				Reisner			
70 sq cm				4 sq cm			
No of Irrad	r per Irrad	Total r	Per Cent	No of Irrad	r per Irrad	Total r	Per Cent
1	525	525	100	1	1000	1000	100
2	400	800	152	2	650	1300	130
3	275	825	157	3	500	1500	150
4				4	400	1600	160
5	185	925	176	5			
7				7	300	2100	210
12	100	1200	228	12	200	2400	240
27				27	100	2700	270

C Additional Data for Longer Intervals				
No of Irrad	Interval (Hours)	r per Irrad	Total r	Per Cent
4	96	300	1200	228

All quantities of radiation measured in air

mains is the consequence of the total ionization produced by the original irradiation. But it is evident that some recovery has taken place, and for purposes of dosage calculation, and of obtaining some idea of the effect of the interval on the cumulative dose, it is convenient to say that *the tissue acts as if a certain part of the radiation remains effective*. For three or more daily treatments, similar calculations can be carried out. For details the reader is referred to the first paper.

In Table I are given the available data for 200 kv x-rays. In addition to the authors' data, those of Reisner (2) for various numbers of daily irradiations are included. Practical applications of these data will now be developed.

A The Calculation of the Cumulative Dose—In the earlier paper it was shown that the recovery during the second day of

treatment was 31 per cent, or that 69 per cent of the cumulative dose remained effective when the third treatment was to be administered, and 24 hours after the third treatment, 74 per cent. Corresponding figures obtained from Reisner's data were 65 and 74. By carrying out similar calculations for data from longer treatment periods, the values have been obtained from which the curves of Figure 1 were plotted. Points obtained from the authors' data are indicated by circles, those from Reisner's by crosses.² A single additional point can be obtained from the data published by Löw-Beer and Redisch (3) and is indicated by a triangle. The upper curve, which is

² It should be noted that Reisner has made no calculations of this sort. He has determined the various fractionated doses required to produce his standard reaction but has drawn no conclusions from them regarding recovery. The authors have simply applied their methods of calculation to his published data.

well covered experimentally, shows the percentage of the cumulative dose at any day of the treatment period, when daily irradiations are given. Its use is best illustrated by an example.

Example Calculate the daily cumulative dose when 300 r are administered to a given field daily for five days.

First day—300 r administered (1)

Second day—45 per cent remains effective
 $0.45 \times 300 = 135$

Add 300 r $300 + 135 = 435$ r effective

Third day—65 per cent remains effective
 $0.65 \times 435 = 280$

Add 300 r $300 + 280 = 580$ r effective

Fourth day—71 per cent remains effective
 $0.71 \times 580 = 415$

Add 300 r $300 + 415 = 715$ r effective

Fifth day—75 per cent remains effective
 $0.75 \times 715 = 535$

Add 300 r $300 + 535 = 835$ r effective

That this is a reasonable value for the cumulative dose is demonstrated clinically by the fact that the skin reactions produced by a single dose of 825 r and by five daily doses of 300 r are about the same.

In order to find the accumulated dose at any time by means of these curves, it is necessary to go through the type of calculation indicated in these figures. It would be convenient if this could be avoided. For any definite scheme of irradiation, such calculations can be made once for all, and the results tabulated for ready reference. Table II provides these data, for 100 r administered daily, or every two, three, or four days, the accumulated dose, in "effective roentgens," at any day of the treatment period, may be read directly. For individual doses of any other magnitude, the accumulated dose at any day will be in the same ratio to that in the table as the daily dose is to 100 r.

The lower curves of Figure 1, for irradiations every second, third, or fourth day, are not as well covered experimentally as the first, but there are enough points to indicate that they must be approximately correct. The work involved in verifying points on the curves is considerable, for each one requires tests on several patients.

TABLE II—ACCUMULATION OF RADIATION DOSE IN SKIN DURING TREATMENT PERIOD

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	Accumulated Dose—'Effective Roentgens'			
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6	320			
7	360	205	160	
8	400			
9	440	240		150
10	480		190	
11	520	275		
12	565			
13	610	310	220	175
14	655			
15	700	340		
16	745		250	
17	790	370		205
18	835			
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21	980	430		235
22	1025		315	
23	1070	465		
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25	1165	500	350	265
26	1220			
27	1275	535		
28	1330		385	
29	1385	570		310
30	1440			
31	1500	605	425	
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35	1730	685		

It is evident that no serious error exists in this group of curves. Figures 2 and 3 show the day-by-day accumulation of dose, in special cases, calculated as above.

B The Effect of Varying the Fractionation of the Irradiation—From Figure 3 it is suggested that if the total dose and total treatment time are the same, within certain limits, the number of fractions into which the radiation is divided is not particularly important. This is borne out by a number of experimental observations which are summarized in Figure 4. Reisner has also observed this fact, in administering to one field 12 daily doses of 20 per cent each, and to another four doses of 60 per cent each, on

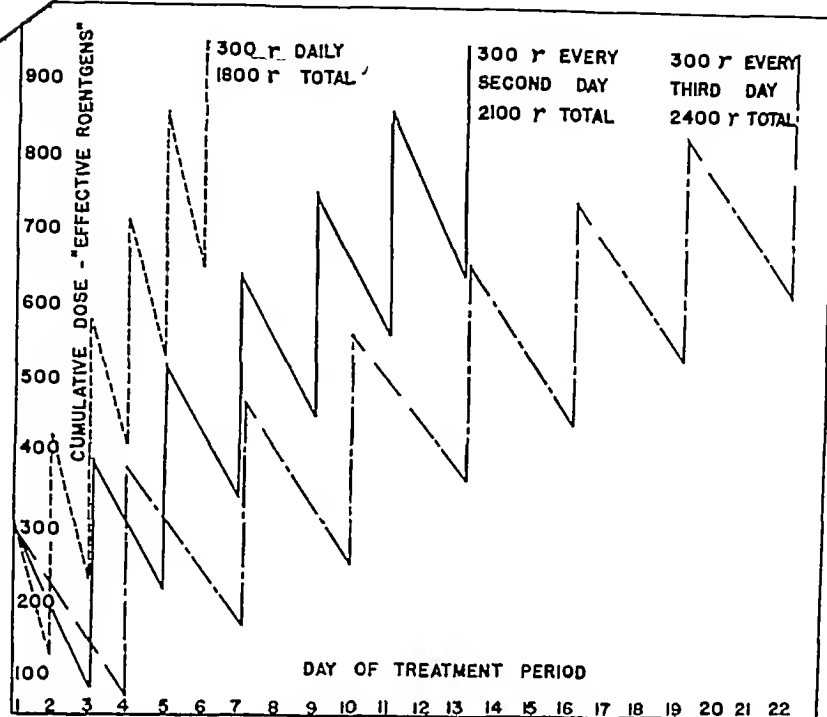


Fig 2 Accumulation of radiation effect in the skin 200 kv x rays The individual doses are the same, the intervals between them vary in the three series

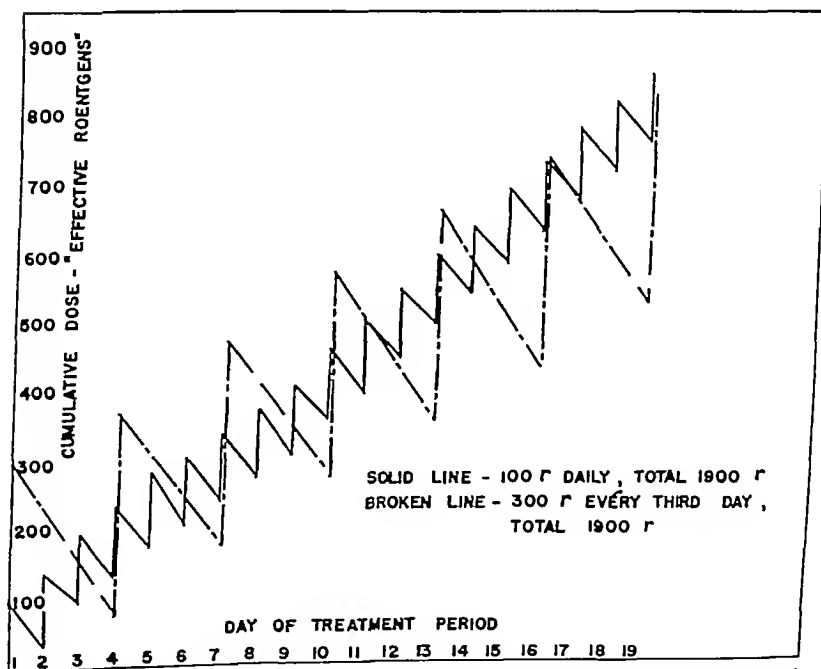


Fig 3 Accumulation of radiation effect in the skin 200 kv x rays The total dose and the total irradiation period are the same the individual doses and the intervals vary in the two series

the first, third, seventh, and twelfth days. This point may be of practical importance in the busy x-ray department, or in cases in

cases the total treatment period, that is, the entire time within which the treatments are given, is the same, although the

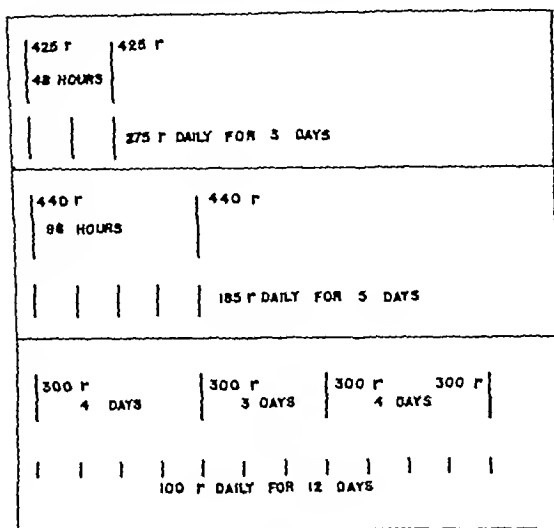


Fig 4

Fig 4 The effect of varying the fractionation of the irradiation 200 kv x rays. The members of each pair of irradiation schemes produce the same effect on the skin, the total doses and total treatment periods are approximately the same, but the fractionation varies.

Fig 5 The effect of varying the intensity of the radiation gamma rays. The members of each pair of irradiation schemes produce the same effect on the skin, the total doses and total treatment periods are essentially the same, but in one case the irradiation is continuous and in the other intermittent.

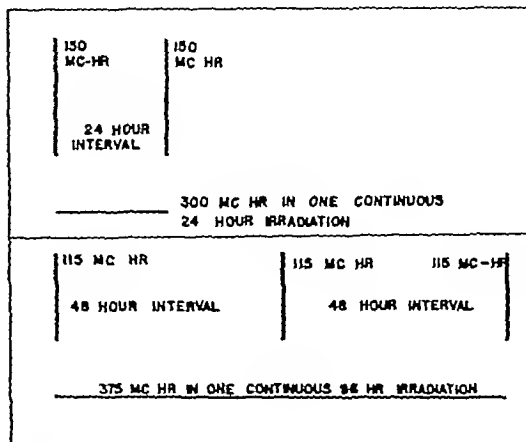


Fig 5

which a patient comes a long distance for treatment. If daily irradiations produce no better result than treatment of two or three times the amount every two or three days, it may be an advantage not to insist on them. *It should be noted here, however, that these data refer only to skin. The clinical applicability of the information can be determined only by observing the tumor regression, systemic effect, etc., in series of cases treated by each scheme.*

C. *The Effect of Varying the Protraction of the Irradiation*—It is well known that if the intensity of the radiation is reduced, a greater amount is necessary to produce a specified reaction, when the treatment is given in one sitting. If, however, the radiation of higher intensity is administered in two equal doses, one during a short time at the beginning and the other at the end of the longer period required for the low intensity radiation, in certain cases it has been found that the difference disappears; the same amounts of both types of radiation produce the same reaction. In these

actual irradiation time is much longer for the low intensity radiation than for the high. In the case of the high intensity, recovery takes place between treatments, in the case of the low, recovery and production of radiation effect are simultaneous. Within certain limits it appears that if the total dose and total treatment period are the same, the rate at which the radiation is administered within that period is not important, it may be continuous or fractionated at will. This point can be more readily studied with gamma rays than with x-rays, since with radon tubes of various strengths available, it is easy to obtain radiation of any desired intensity. Figure 5 shows experimental results in two such cases. In these it is evident that it makes no difference whether the irradiation is continuous or intermittent, provided the total dose delivered in a given time is the same. Allowance was, of course, made for the change in strength of the radon source. The fact that the intensity at the end of the four-day period was slightly less than

as at the beginning is prob- minutes to two hours In both groups t
significance, in the literature on average result on both fields was the sam
ject, the earliest change noted in He then tested the effect in the gamm

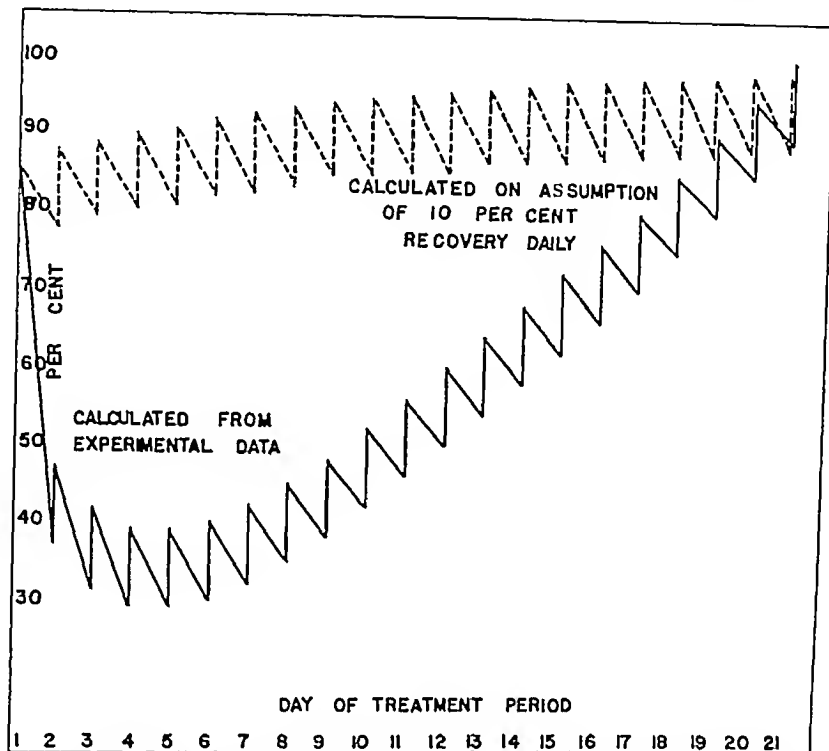


Fig 6 Calculation of accumulated dose in the skin for "saturation technic" on the basis of a constant recovery factor, and on the basis of the experimentally determined values. The treatment consists in the administration of 85 per cent of the threshold dose the first day and 10 per cent daily thereafter for three weeks.

the reaction is for a considerably greater change in the intensity than this

It should be noted that in the experiments herein reported, both on the effects of fractionation and of protraction, each pair of treatments was tested not on one, but on several, individuals

The effect of protraction has also been studied by McWhurter (4), both with gamma and x-rays. For each type of radiation he used a wide range of variation of intensity in erythema tests, delivering the same total dose to two corresponding fields in periods of one week. With x-rays, one field always received radiation at more than twelve times the rate of the other, in each case seven daily treatments were given. For gamma rays, one field received continuous irradiation for seven days, the other, daily irradiations of from fifteen

ray treatment on a small group of superficial tumors, and came to the conclusion that these lesions responded in the same way as the skin, that is, that the rate of administering the daily treatments was not significant

D The Question of the "Saturation Technic"—In the previous paper, the authors discussed the calculation of accumulated dose on the "saturation" basis, and showed that the generally used factors gave dosage totals much higher than those actually delivered. At the same time, Pfahler (5) stated that this must be the case, and that all "saturation factors" previously published should be increased, that is, that the daily recovery was greater than had been assumed. Other radiologists have since expressed the same belief, and it has been suggested that 9 or 10 per cent daily

must be about right for 200 kv x-rays, because treatment administered on this basis results in the appearance of the expected. creases the repair is less, until a point is reached from which there is no recovery. Any satisfactory method of calculating ac-

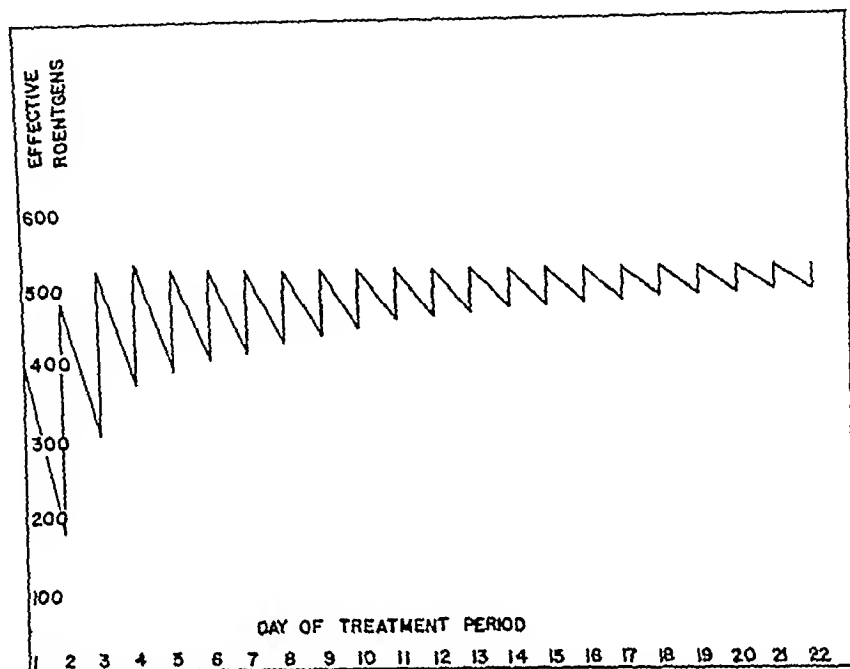


Fig 7 Accumulation of radiation effect in a true saturation method of treatment
For details of irradiation, see text

skin reaction It is of interest to compare the calculation of accumulated dose on this basis and on that based on the experimental results, as shown in Figure 6. It is seen that, at the time the reaction appears (about the third week), both methods have led to the same result. However, this would not be the case if treatment were not carried out over just this period, and for just these divisions of dose. For longer times, the value based on a constant recovery factor would be lower than the actual one, for shorter times it would be higher. For larger individual doses, the value thus calculated would mount much too rapidly. The coincidence shown is, therefore, only a coincidence and not a justification of this method of calculating dosage. It is evident from clinical considerations that no constant recovery factor can be right. Skin recovers from a first irradiation much more rapidly than from any subsequent one, and as the damage in-

cumulated dose must take this into consideration.

It is apparent that the term "saturation method," applied to the administration of a fairly large dose followed by a number of small ones, supposing a constant rate of recovery, and a constant rate of making up for this, is not accurate. Of the clinical value of such a method of administering radiation, no judgment is to be passed from the data included in this paper. However, if a "saturation method" is to be designed to maintain the tissues continually in the same state as regards the effective radiation present, replacing each day what has been lost, it is evidently necessary to know the loss for every day. Any assumption regarding a constant rate of loss of radiation effect is completely unwarranted, in view of the experimental evidence here presented. A true saturation scheme can be worked out from the curves of Figure 1, for maintaining the dosage at any desired

Example, calculate the daily dose bringing the skin to the threshold in two or three days, and to maintain there for two weeks. The first steps of the calculation are given below, the complete course in Figure 7

First day—400 r administered

Second day—45 per cent remains effective

$$0.45 \times 400 = 180$$

Add 300 r $300 + 180 = 480$ r effective

Third day—65 per cent remains effective

$$0.65 \times 480 = 310$$

Add 215 r, arriving at the threshold dose

$$310 + 215 = 525 \text{ r effective}$$

Fourth day—71 per cent remains effective

$$0.71 \times 525 = 375$$

It is necessary to add $525 - 375 = 150$ r

$$375 + 150 = 525 \text{ r effective}$$

Fifth day—75 per cent remains effective

$$0.75 \times 525 = 395$$

It is necessary to add $525 - 395 = 130$ r

$$395 + 130 = 525 \text{ r effective}$$

Sixth day—78 per cent remains effective

$$0.78 \times 525 = 410$$

It is necessary to add $525 - 410 = 115$ r

And so on for any desired period

To the knowledge of the authors, such a scheme of treatment has never been carried out. It is hoped that it may be tried in the near future, and the results compared with those obtained by other methods

SUMMARY

Further experimental data have been collected on the recovery of human skin from roentgen and gamma-ray irradiation

Curves and a table are given from which the accumulated dose in the skin can be

calculated, for any day during the treatment period

It is shown that if sufficient radiation be administered in a given time to produce the threshold effect, within the experimental limits investigated it makes no difference whether it is delivered in small doses with short intervals, or in larger ones with longer intervals

It is further shown that if the radiation be administered in a given period, it makes no difference, within the experimental limits investigated, whether it is delivered in long treatments of low intensity or in short ones of low intensity

The saturation method of dosage calculation is discussed. It is shown that this term cannot be justified when a constant daily recovery factor is assumed. Since the amount of recovery decreases from day to day, it is necessary to know the correct recovery factor for every day. A method is outlined for calculating a true saturation scheme of irradiation

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THE BIOLOGICAL ACTION OF NEUTRON RAYS¹

By ERNEST O. LAWRENCE, PH D, D Sc, *Berkeley, California*

NEUTRON rays have the remarkable property of being more readily absorbed in light substances rich in hydrogen such as biological tissues than in denser substances like iron or lead. If you should use a fluoroscope and look through the body with neutron rays, you would find that the bones would appear relatively transparent and the flesh would look darker. Neutron rays also are unique in the manner in which they produce ionization. X-rays produce ionization by liberating high speed electrons from atoms, while neutrons, being tiny dense particles of neutral matter, pass right through the electron clouds of atoms and ionize only by making intimate collisions with the correspondingly dense atomic nuclei.

The great difference in the mode of ionization by neutrons and γ -rays can actually be photographed, thanks to the ingenious cloud chamber method of C. T. R. Wilson, which makes use of the fact that fog droplets form on ions in an atmosphere of supersaturated water vapor. Ionization in the Wilson cloud chamber thus can be seen in detail in the sense that each ion can be made to manifest itself as a visible fog droplet. Figure 1 is a cloud chamber photograph of the ionization in a chamber filled with a mixture of hydrogen, oxygen, nitrogen, and water vapor produced by a mixture of gamma rays and neutron rays from the cyclotron. You see some very thin lines of fog droplets. Indeed, you can see some of the individual droplets of these tenuous ionization tracks. These were produced by the high speed electrons liberated by the gamma rays which in passing through the chamber produced only a few ions per centimeter of path. This is the sort of ionization produced by γ -rays.

The much thicker and much more dense ionization tracks were produced by neutrons. At one end of a dense track, a

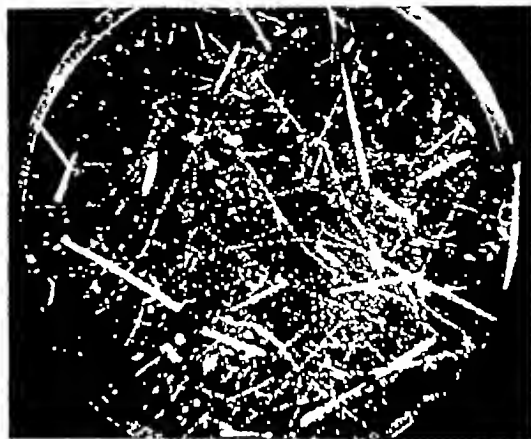


Fig 1 Wilson cloud chamber photograph of ionization in a mixture of air, hydrogen and water vapor produced by neutron rays and gamma rays from the cyclotron. The thin tracks of ions were produced by secondary electrons liberated by the gamma rays while the thick and very dense tracks were produced by the recoil protons resulting from collisions of neutrons with the hydrogen atomic nuclei. This picture gives a general impression of the great difference in the distribution of ionization in tissues produced by neutron rays and γ rays. In comparison to γ ray ionization neutron ionization is very much more localized and intense.

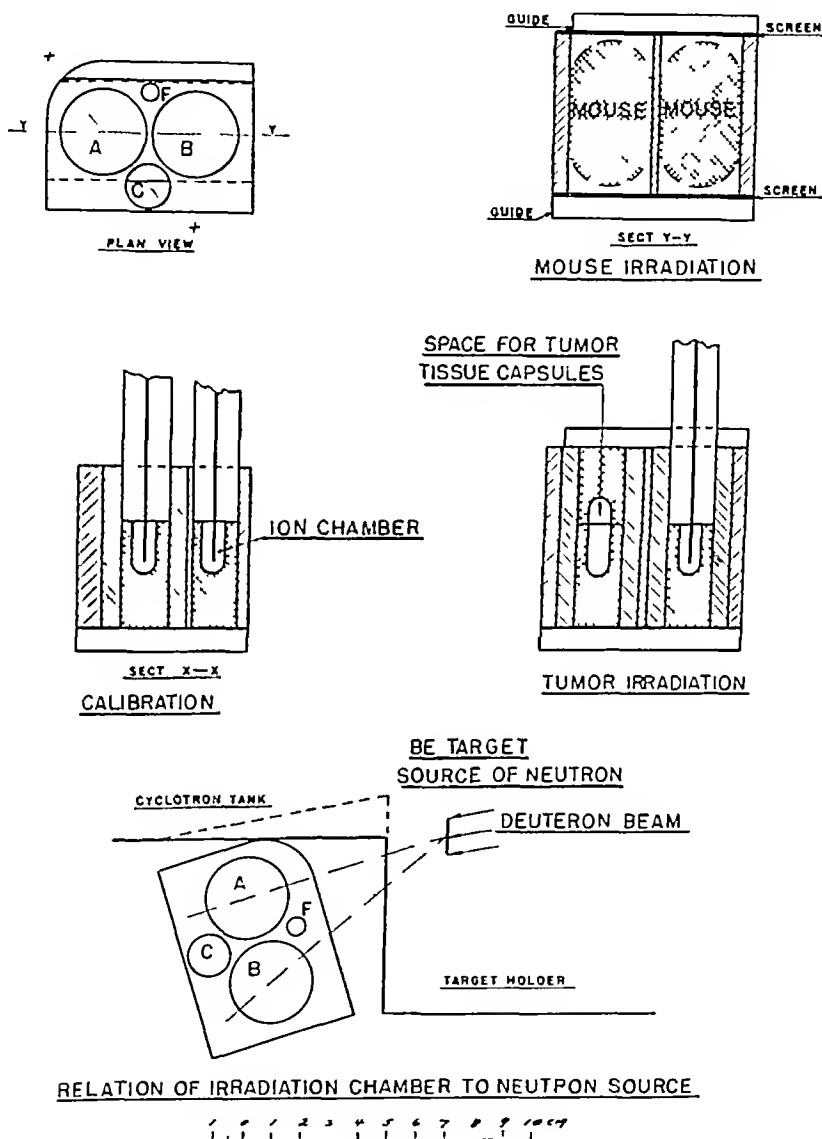
neutron struck a hydrogen atomic nucleus, a proton, and the proton recoiled with tremendous energy. The recoil proton, being a heavy charged particle, rapidly dissipated its energy by producing very intense ionization over a short distance—before coming to rest and picking up an electron, thus becoming an ordinary hydrogen atom again. The heavy fog tracks in the cloud chamber several inches long were produced by recoil protons having energies of more than a million volts. Electrons of such energies would make ionizing tracks a hundred times longer. The ionization produced by a recoil proton is something like one hundred times more dense than that produced by an γ -ray secondary electron, and so we see that neutron ionization, in comparison

¹ Read before the Radiological Society of North America at the Twenty-second Annual Meeting in Cincinnati, Nov. 30-Dec. 4, 1936.

with γ -ray ionization is very much more localized and very much more intense where it occurs

According to some theories of the biological processes induced by ionization it is the total amount of ionization and not the

ARRANGEMENT FOR NEUTRON IRRADIATION AND DOSAGE MEASUREMENT



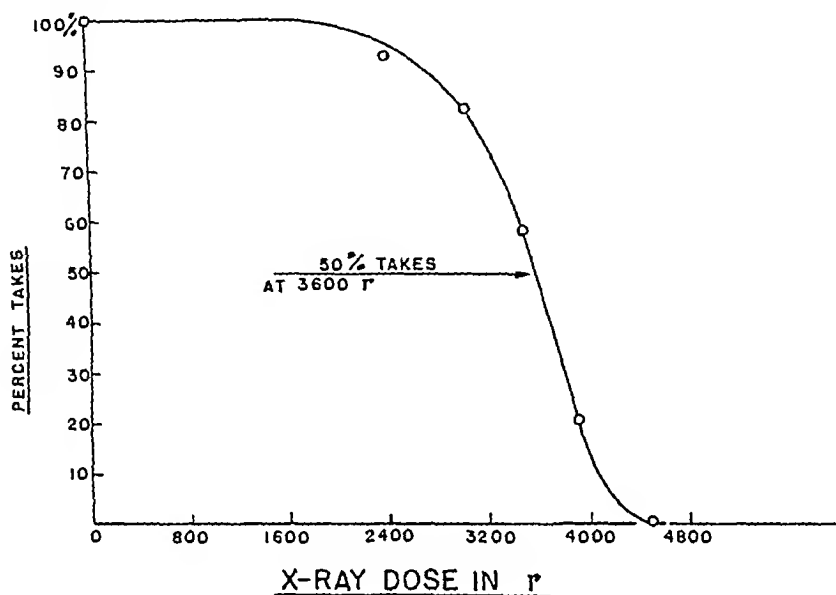
In view of this great difference in the physical behavior of neutrons and γ -rays, one is led to wonder whether the two forms of radiation are also very different in their biological action

The questions here involved are of both theoretical and practical interest. Ac-

distribution in a biological system that is of importance, a point of view which would indicate that neutron rays would parallel γ -rays completely in their biological action. Observations of differences in biological effects produced by the two radiations would therefore contribute sig-

significantly to our understanding of biological effects of neutrons and γ -rays have recently been carried out. Perhaps I should mention this in mind as well as the possibility that remark here that these experiments were

X-RAY IRRADIATED MAMMARY CARCINOMA IMPLANTS



NEUTRON IRRADIATED MAMMARY CARCINOMA IMPLANTS

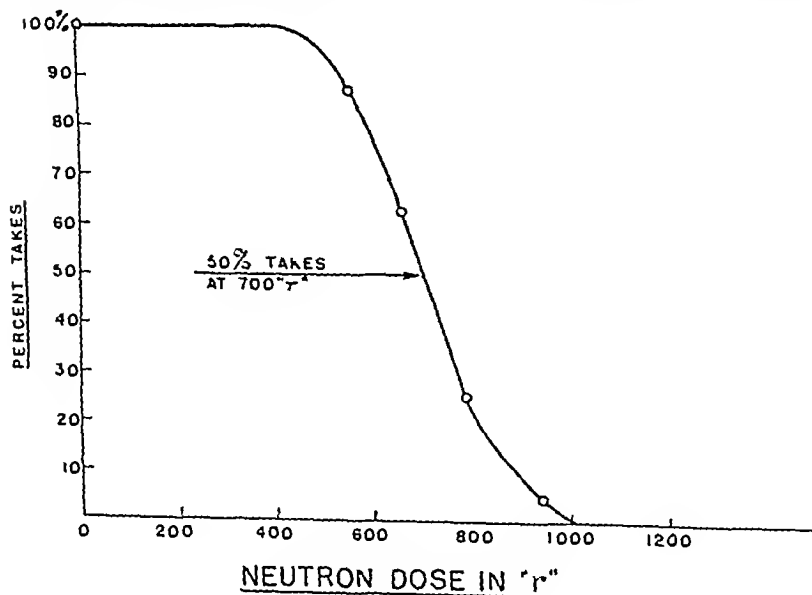


Fig 3 (upper) Fig 4 (lower)

neutron rays might have valuable practical applications, some experiments in our laboratory on the comparative biological effects of neutrons and γ -rays have recently been carried out. Perhaps I should mention this in mind as well as the possibility that remark here that these experiments were originally undertaken for the immediate practical purpose of obtaining information for the protection of workers in our labo-

ratory We did not want to repeat the unfortunate experiences of many of the early roentgenologists It was fortunate

indicating a greater biological effect per unit of ionization for the neutron rays These early experiments have been pub-

COMPARISON OF LETHAL POWER OF NEUTRONS AND X-RAYS WHOLE BODY IRRADIATION OF NORMAL MICE

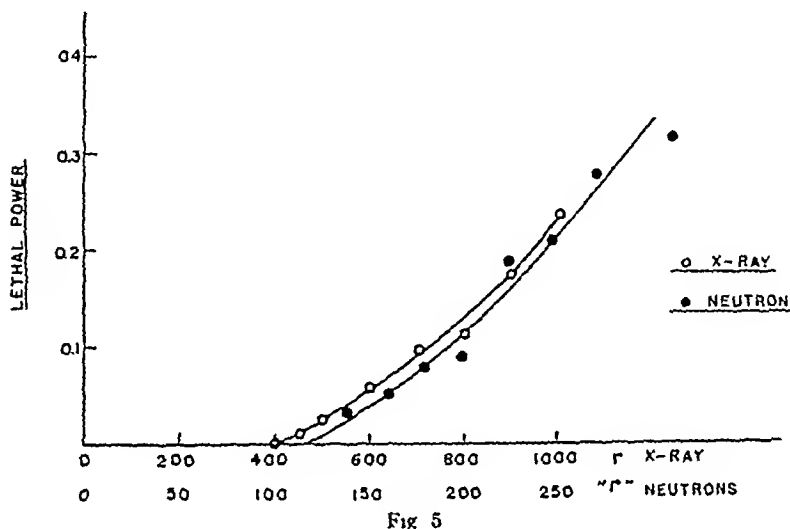


Fig 5

that my brother, Dr John H Lawrence of the Yale University School of Medicine, was visiting me the summer before last and took the occasion to look into this vital question

First of all he placed some rats near the source of neutrons and found immediately that the neutron rays are indeed very lethal and that they kill a rat by a few minutes' exposure When I say kill, I mean that the rats died in about two or three days' time after exposure In these first experiments, studies of the effects of both γ -rays and neutrons on the blood counts of rats were made, which also indicated that for the same total amount of ionization in tissue of the animals, the neutrons were more effective than γ -rays That summer Dr R E Zirkle, of the Johnson Foundation of Medical Physics of the University of Pennsylvania, also spent a period of time in our laboratory and studied the comparative effects of neutron rays and γ -rays on the growth of wheat seedlings, with results likewise

lished² and I have not time to go into them here, excepting to say that they more than gave us information as a basis for providing protection for us in the laboratory, for they gave indications that neutron rays have different selective actions on biological substances when compared with γ -rays In comparison with the action of γ -rays, the neutrons seemed to be relatively more effective on the wheat seedlings than on the blood counts of the rats Because, as I have already indicated, this possibility of a different selective action by neutrons is of much theoretical interest, and also because it has its immediate practical implications—for, as you all know, an important factor in radiation therapy is the selective action of radiation on tissues—my colleagues have

² Zirkle, R E and Aebersold P C Relative Effectiveness of X rays and Fast Neutrons in Retarding Growth Nat Acad Sci February 1936 22, 1934-1938

Lawrence J H and Lawrence E O The Biological Action of Neutron Rays Proc. Nat Acad Sci February 1936 22, 124-133

been impelled to continue with the experimental investigations I should like now to give you a brief account of some of the about one centimeter, at a distance of about seven centimeters from the beryllium target of the cyclotron, which is the source

NEUTRONS & X-RAYS ON 5 OBJECTS

	RATIO	
MAMMARY CARCINOMA $\left\{ \begin{array}{l} \text{X-RAY } 3600 \mu \\ \text{NEUTRON } 700 \mu \end{array} \right\}$	5.1	
NORMAL MICE [LETHAL POWER]	3.8	
DROSOPHILA EGGS $\left\{ \begin{array}{l} \text{X-RAY } 180 \mu \\ \text{NEUTRON } 87 \mu \end{array} \right\}$	2.1	[ZIRKLE & AEBERSOLD]
WHEAT SEEDLINGS $\left\{ \begin{array}{l} \text{X-RAY } 600 \mu \\ \text{NEUTRON } 120 \mu \end{array} \right\}$	5	"
FERN SPORES $\left\{ \begin{array}{l} \text{X-RAY } 52,000 \mu \\ \text{NEUTRON } 21,000 \mu \end{array} \right\}$	2.5	"

Fig. 6. Summary of comparative effects of x-rays and neutron rays on five biological objects showing that the ratio of the doses of the two forms of radiation required to produce the same biological action in the several instances varies from 2.1 to 5.1. These results show that neutrons have a selective action on biological substances which in general is different from that of x-rays.

recent results. My associates will doubtless publish a more detailed report of their work elsewhere.

It was, first of all, of interest to determine as definitely as possible whether or not neutrons do have a different selective action on biological substances when compared with x-rays, and for this purpose Dr. R. E. Zirkle, Mr. P. C. Aebersold, and Mr. E. R. Dempster chose to study three biological effects, namely, the killing effects of the radiations on *Drosophila* eggs, the growth inhibiting effect on wheat seedlings, and the inhibiting effects on the fern spore, *Pteris longifolia*. These biological objects, being small, were admirably suited for the work, because it was possible to irradiate large numbers of individuals in a comparatively small volume so that statistical fluctuations could be made small and the objects could be placed rather close to the neutron source without producing serious errors due to the inverse square law, i.e., the variation of intensity of radiation over the biological objects.

The several biological materials were placed in small capsules in a hole in a wooden block, the hole having a diameter

of the neutrons. The dosage of neutrons was measured by a Victoreen condenser meter (which may be called the dosage indicator) inserted in an adjacent hole in the wooden block. The dosage indicator of course was readily calibrated in terms of the radiation intensity in the hole containing the biological specimens. Time does not permit going into a discussion of neutron dosage measurement here, although we have carried out some experiments which indicate that the neutron dosage measurements obtained with the Victoreen meter are approximate indications of the ionization in ordinary biological tissues. The question of absolute ionization in tissue in relation to the dosage measurements is here not essential, as we are interested at this time only in dosage ratios and can regard the dosage measurements as in arbitrary units.

Dr. Zirkle, Mr. Dempster, and Mr. Aebersold found that about 87 r of neutrons kills about one half of the flies' eggs, while for x-rays they found that it takes about 190 r to produce the same effect—in line with the well established values of Packard and many others. In other words, it was found that, in terms of

the Victoreen measurements, the neutrons are about twice as effective as γ -rays. In the case of the fern spore, Dr Zirkle and

has been published,³ and I need only mention here that they did give indications that neutron rays do have on this

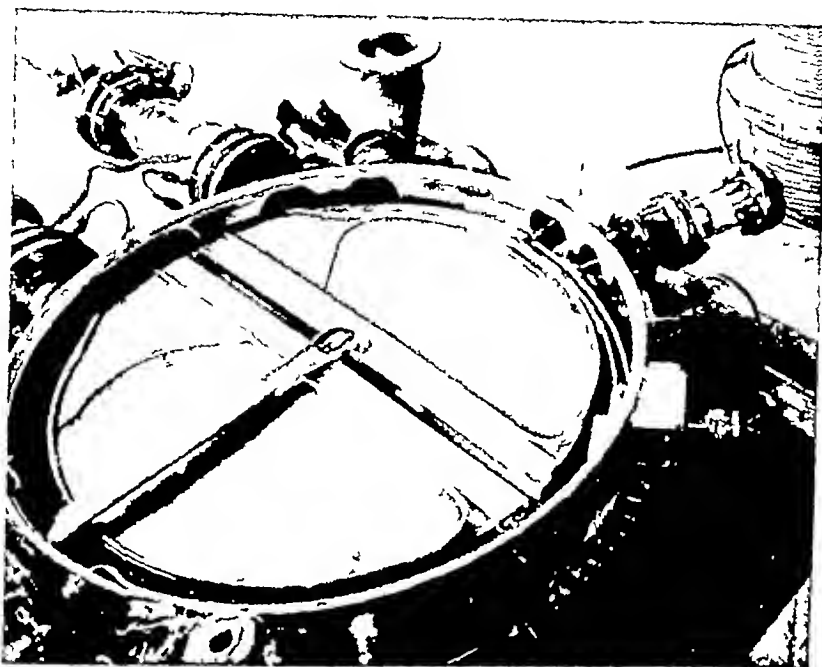


Fig 7 View of cyclotron vacuum chamber with cover plate removed

Mr Aebersold found that the neutrons are about 25 times as effective as γ -rays. Thirdly, they found that, in inhibiting the growth of wheat seedlings, the neutrons are about five times as effective as the γ -rays.

I think we can say that these experiments established quite definitely that neutron rays and γ -rays do not parallel each other in their biological action. The selective action of neutron rays on tissue is in general different from that of γ -rays.

This result immediately raises the very important question of the action of neutron rays on tumor tissue—whether the neutrons have a greater selective action than γ -rays. The first experiments on this question were carried out by Dr John Lawrence on the experimental mouse tumor, Sarcoma 180, which was very kindly supplied by Dr Francis Carter Wood. An account of these experiments

tumor a greater selective action than γ -rays in the ratio of about 4 to 3.

Recently Dr Lawrence and Mr Aebersold have studied⁴ the comparative effect of the two radiations on another mouse tumor, a mammary carcinoma, obtained from Dr Strong, of Yale. This mammary carcinoma, like the Sarcoma 180, is an easily transplantable tumor so that it could be dissected from one animal, cut up into small tumor particles, exposed to the radiations *in vitro*, and then injected into many animals, following which the ultimate growth of the tumors in the animals could be observed at various times up to several months. The tumor particles were wrapped in filter papers, moistened with suitable physiological solu-

³ Lawrence, John H. Aebersold P. C. and Lawrence E. O. Comparative Effects of X rays and Neutrons on Normal and Tumor Tissue. *Proc Nat Acad Sci* September 1936, 22, 543-557.

⁴ These biological investigations were aided by a grant from the Josiah Macy Jr Foundation.

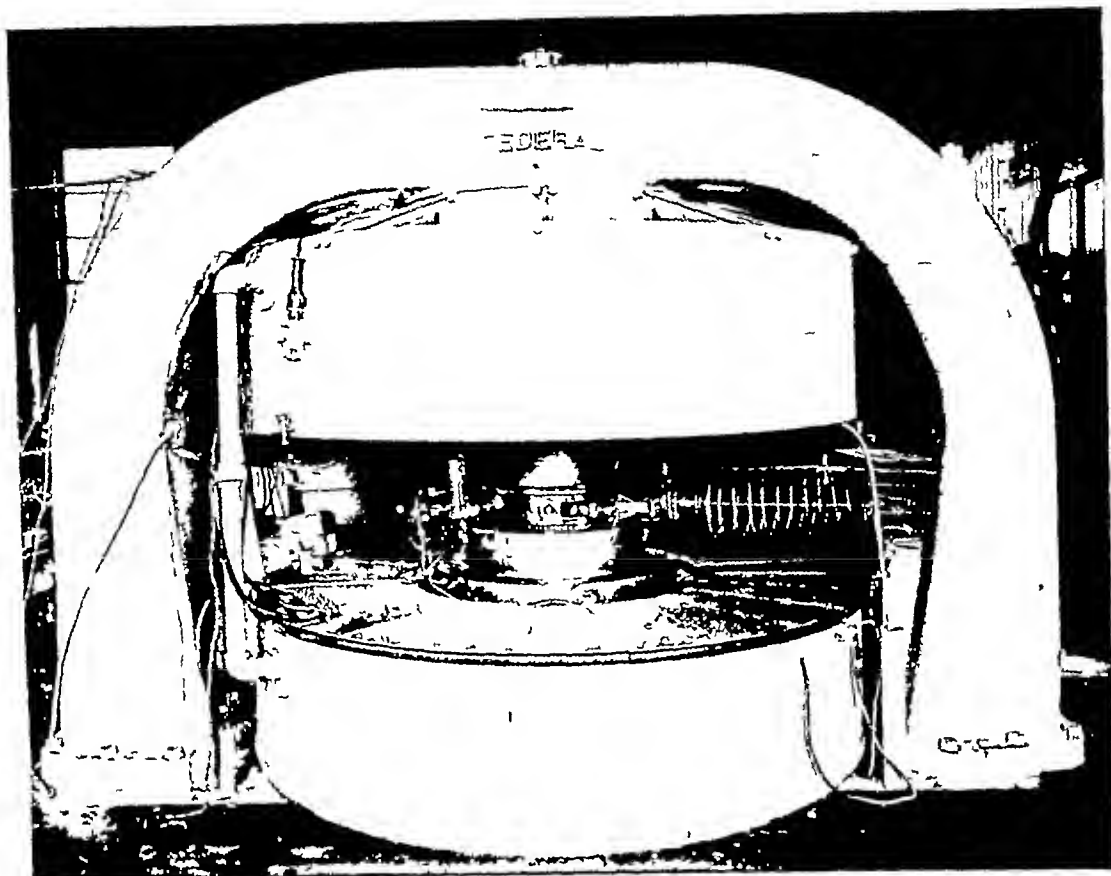


Fig 8 General view of the cyclotron

tions, and then placed in a capsule in a hole in a wooden plug block which had dimensions about equal to those of a mouse. The reason for placing the capsule in the plug of wood was to insure that the tumor particles were exposed to about the same quality of radiation as would be produced on the interior of a mouse exposed to the radiation at the place occupied by the wooden plug. As I shall bring out more clearly later, mice were also exposed to the neutrons, for it was the purpose of the experiment to compare the effect on the tumors and on the mouse as a whole. The plug of wood, as shown in Figure 2, fitted into a suitable hole in a larger wooden block. This abundance of wood surrounding the biological objects tended to produce a homogeneity of radiation over the irradiated substances.

Figures 3 and 4 show the results of the observations both with neutrons and with

x-rays. More than a thousand tumor particles were exposed to the radiations so that statistical fluctuations were small and the results quite definite. We see that an x-ray dose of about 4,500 r was required to kill all of the tumors, while 50 per cent were prevented from growing in the mice by an exposure to 3,600 r. Now turning to the neutron experiments, we see that similar curves are obtained, shown in Figure 4. Here we see that about 1,000 r kills them all and that the 50 per cent point comes at 700 r, so dividing 3,600 by 700, we see that the neutrons are about 5.1 times more lethal.

Now, of course, from the standpoint of the possibility of radiation therapy the fact that neutrons are five times more lethal on tumors than x-rays in itself is not of particular significance, for it is the selective effect, the relative effect on the tumor in relation to the surrounding healthy



Fig 9 Photograph of beam of 5.8 million volt deuterons emerging into the air through a platinum window in the wall of the cyclotron chamber

tissue, that is of importance. In order to get one measure of the comparative effect of neutrons on healthy tissue, mice as a whole were exposed to both neutrons and α -rays and the lethal effects observed. Hundreds of mice were exposed to various doses of both forms of radiation and the effects on the subsequent lives of the animals were observed for several months. As a convenient indication of the lethal effect on the healthy mice we adopted as a measure what might be called the "lethal power" of the radiation, which is the reciprocal of the number of days the animal lives after exposure to radiation. Thus, if the animal lives a very long time, the reciprocal of the number of days is a very small number, and accordingly the lethal power is very small. If the animal lives a short time, for example, two days, the lethal power is one-half, which is on this scale a large lethal power. The average lethal powers for the large number of animals exposed at various doses is

shown in Figure 5. Here we see that nice smooth curves are obtained and the curves are nearly superposable with the abscissa of the dosage scale for the α -rays four times larger than that for the neutrons. The 120 r of neutrons just produced a perceptible killing effect on the healthy mice, while it takes about 400 r of α -rays to do the same thing. In other words, for a detectable lethal effect, the neutrons are about 3.3 times as effective as the α -rays, while for larger lethal powers the ratio approaches 4 and we may take 3.8 as an average ratio.

Results of all these experiments are summarized in Figure 6. For the small biological objects that have been recently studied, for which the dosage measurements are of greatest precision, it is found that the ratio of the biological effectiveness of α -rays and neutrons varies all the way from 2.1 for the flies' eggs to 5.1 for the mammary carcinoma. We could express these ratios the other way around

For example, in therapy one is interested in the effect on the tumor relative to the effect on the host, the mouse in these experiments. The ratio of the 50 per cent tumor dose to the perceptible killing mouse dosage for α -rays is 3,600 divided by 400, a ratio which is 9. In other words, the mouse can tolerate over its whole body only one-ninth the dose of α -rays required to kill 50 per cent of the tumor particles *in vitro*. With neutrons the ratio is 700 divided by 120, that is, 5.8. Instead of only one-ninth the tumor dose, the mouse can stand about one-sixth of the 50 per cent tumor killing dose and so we see that the experiments indicate that a more effective dose on the tumor using neutrons can be given without killing the mouse.

If these indications of a greater selective action of the neutron rays on tumor tissue prove to be true for carcinomas *in vivo*, it is a very important matter. My colleagues, Dr. John Lawrence and Mr. Aebersold, as well as myself, regard these observed ratios as preliminary and we are still looking for possible systematic errors in the experiments. We have, however, all along looked very carefully, and as far as I can see, these results are approximately right.

Now in the remaining time I should like to show slides of the apparatus that has been used in these experiments, with a few comments, because you will possibly be interested in whether or not the practical clinical implications of the results here presented are really of more than laboratory and scientific interest, whether it is really a practical matter to use neutron rays in medical therapy as you use your α -ray machines.

Instead of bombarding a target of a heavy metal with high speed electrons, as is done in the production of α -rays, neutron rays are produced by bombarding a target of a light metal, notably beryllium, with very energetic deuterons, the nuclei or ions of heavy hydrogen. In order to produce sufficient intensity of the neutron radiation from the beryllium target for the purposes of biological work, it is necessary to bombard the target with

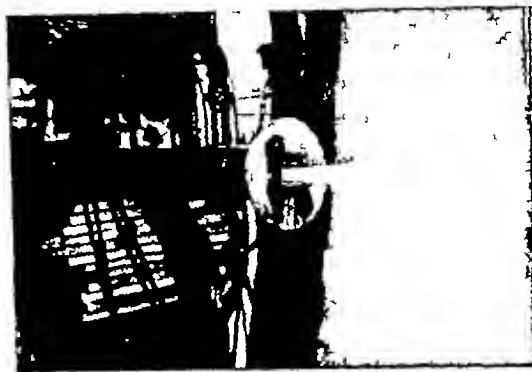


Fig. 10 Here the energetic beam of atomic projectiles (5.8 million volt deuterons) emerges 6 feet from the chamber wall at the end of an attached vacuum tube.

deuterons of several million volts of energy, because the production of neutron rays increases rapidly with voltage. In our laboratory the deuterons are accelerated to these high speeds by causing them to spiral around between the poles of a large electro-magnet under the combined action of the magnetic field of the magnet and a high frequency oscillating electric field. I need not go into the details of the apparatus called the cyclotron, which does this, excepting to say that the ions are accelerated in a drumlike vacuum chamber spiralling around inside the semicircular hollow electrodes and finally emerging at the periphery of the chamber, where they are caused to strike the beryllium target. A general view of this vacuum chamber is shown in Figure 7 and the chamber between the poles of the large electro-magnet is shown in Figure 8.

In the present experiments, bombarding currents of about 20 micro-amperes of 5.5 million volt deuterons were used. The biological objects were placed in the wooden receptacle adjacent to the wall of the vacuum chamber (which, however, cannot be seen in this photograph).

I should like to insert here another slide (Fig. 9) showing the beam of energetic deuterons emerging from the vacuum chamber through a thin platinum window into the air. The atomic ions pass through the air for a distance of about ten inches before losing their energy, and in addition

to producing nuclear effects, including neutron rays, they produce α -rays and gamma rays and visible radiation. The beam has a lavender color to the eye and is photographed in a few seconds.

For some purposes it is desirable to direct the beam of deuterons at a target considerably away from the main vacuum chamber and this can be done by attaching a suitable vacuum tube. Figure 10 shows the beam emerging into the air through the platinum window at the end of a brass tube extending six feet out from the cyclotron chamber. Of course, the beryllium target could be placed at the end of this tube, an arrangement that would be obviously convenient for medical purposes.

The magnet shown in the previous slide is much larger than needed for the acceleration of the ions to speeds thus far used. We intend to draw more fully on the power of the magnet soon now and will produce much larger currents of deuterons at high voltages. At the present time the neutron intensities are a bit weak for extensive medical experiments, but with the enlarged apparatus it is probable that the neutron emission from the beryllium target will be effectively equal in biological action to the usual yield of α -rays from a deep therapy α -ray machine.

We have done some experiments on

collimating neutron rays, and find that there are no great difficulties in the way of producing a beam of neutrons suitable for purposes of medical therapy. Instead of using port holes in lead it is necessary to use channels through tanks of water or paraffin or any absorbing substance rich in hydrogen.

The view of the cyclotron which I have shown in the illustrations perhaps gives you the impression that the apparatus is extremely large and costly but it is not so bad as it seems at first sight. At the present time I am of the opinion that a cyclotron can be engineered and developed in a way that will make it entirely practical for the purposes of medicine.

Finally, may I say that these experiments encourage us in the view that the recent discoveries of nuclear physics, notably the neutron rays and the artificial radio-active substances have extremely important bearing on the medical sciences, and so I am glad that through the active interest and generous support of the Chemical Foundation we are now building a new cyclotron designed primarily for medical research and therapy. In another year or so it will be in operation and I do hope that some day I may have the pleasure of coming back here and reporting to you further progress in this new field of radiology.

THE MEASUREMENT OF X-RAYS WITH LIQUID IONIZATION CHAMBERS¹

By LAURISTON S TAYLOR, Physicist, National Bureau of Standards, Washington, D C

TWO years ago, we reported² some preliminary measurements on the ionization produced in liquid carbon disulphide by x-rays. Our interest in the problem lies in its possible application to medical dosage in cases in which we wish to measure the total number of ions produced

deduced by plotting the reciprocal of the current against the reciprocal of the applied voltage, V , and extrapolating linearly to $1/V = 0$. For high fields the plot is nearly linear in accord with Jaffé's theory of columnar ionization (1, 2)

However, when a steady direct current

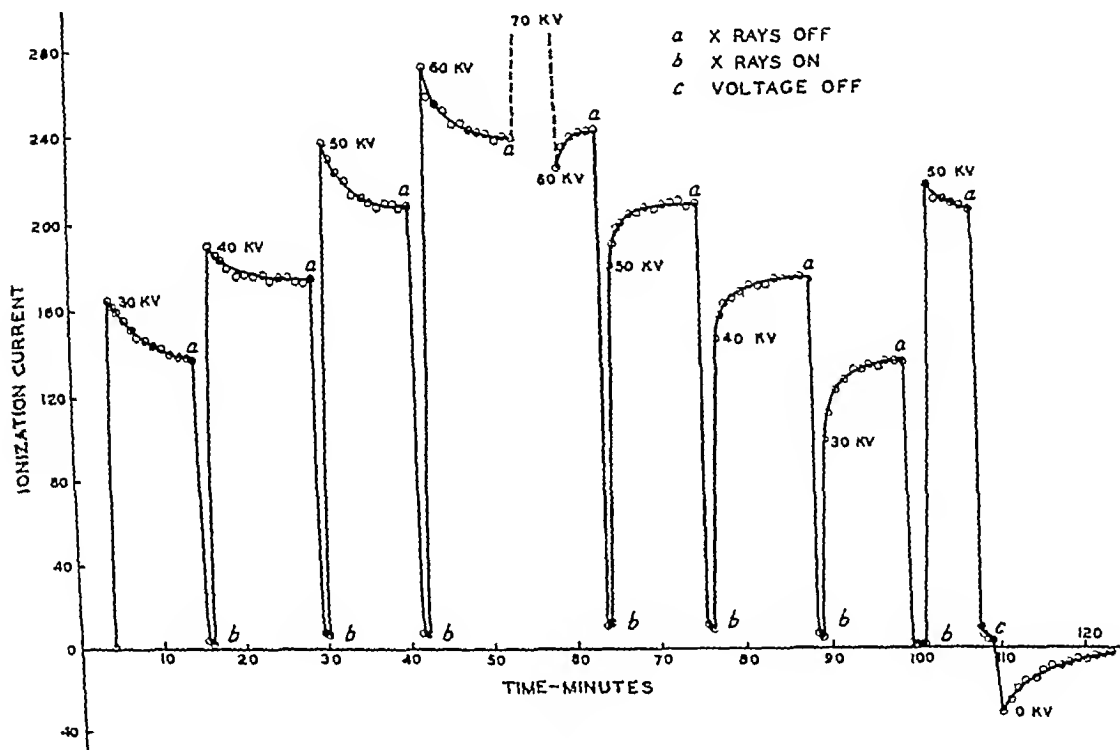


Fig 1

in tissue-equivalent material. While it is impossible to attain saturation conditions in liquids, as is common with gases, we have shown that the saturation current may be

potential is applied to a liquid ionization chamber, a barrier potential arising from a space charge or surface layer is built up, which quickly reduces the field in the liquid to roughly 45 per cent of the applied value. This barrier potential reaches an appreciable value in a small fraction of a second but does not attain its maximum magnitude for about ten minutes, during which interval the measured ionization current decreases exponentially.

¹ Presented before the Radiological Society of North America at the Twenty second Annual Meeting at Cincinnati, Nov 30-Dec 4 1936

Publication approved by the Director of the National Bureau of Standards of the U S Department of Commerce

For a more detailed description of this work see paper by L S Taylor in NBS Jour Research, 1936 17, 557

² At the Memphis meeting of the Radiological Society of North America 1934

Figure 1 shows the measured ionization current, as a function of the lapse of time

to producing nuclear effects, including neutron rays, they produce α -rays and gamma rays and visible radiation. The beam has a lavender color to the eye and is photographed in a few seconds.

For some purposes it is desirable to direct the beam of deuterons at a target considerably away from the main vacuum chamber and this can be done by attaching a suitable vacuum tube. Figure 10 shows the beam emerging into the air through the platinum window at the end of a brass tube extending six feet out from the cyclotron chamber. Of course, the beryllium target could be placed at the end of this tube, an arrangement that would be obviously convenient for medical purposes.

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collimating neutron rays, and find that there are no great difficulties in the way of producing a beam of neutrons suitable for purposes of medical therapy. Instead of using port holes in lead it is necessary to use channels through tanks of water or paraffin or any absorbing substance rich in hydrogen.

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purpose of preventing the segment, d , from picking up a stray charge during the time the electrometer is grounded. In opera-

tion We have consequently selected the time interval involved as that in which no appreciable counter E M F

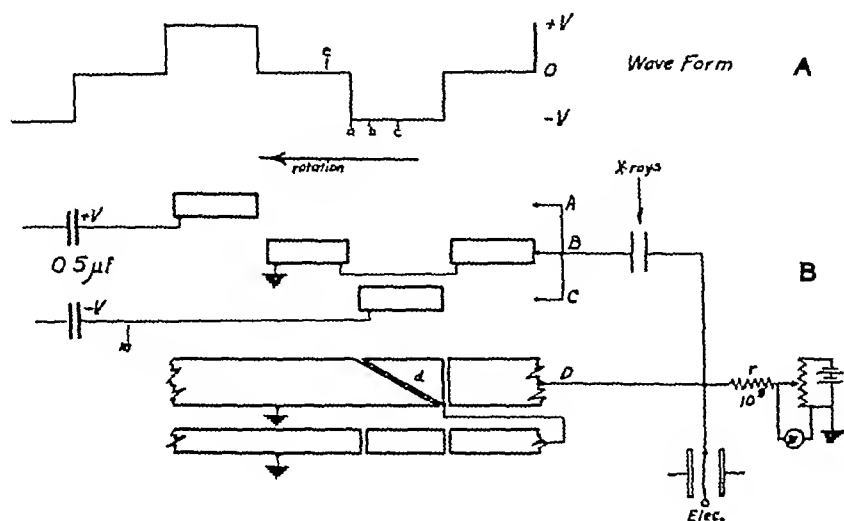


Fig 3

tion, a balance current is applied to the system during the ungrounded interval by means of the potentiometer and high resistance, r , and adjusted until the deflection of the electrometer filament disappears. By this current selector system the current flowing through the cell for intervals as short as 0.0001 second at 0.002, and up to 0.5 second, after application of the voltage can be measured.

To test for the persistence of the barrier potential after each pulse of the square wave potential, the ionization chamber was disconnected from the voltage source at an arbitrary position such as e and at the same time connected to the electrometer. No current was ever noted within the range of alternation frequencies employed.

Figure 4 shows, under a field of ± 50 kv/cm applied to the chamber, the variation of ionization current with lapse of time, T_0 , between the application of voltage and the measurement of the ionization current. Following the sequence of our measurements, with decreasing T_0 , the current increases, reaching a somewhat steady value at a (0.03 sec) and continuing down to b (0.02 sec). This constant value is revealed repeatedly under the various conditions of

or barrier potential has been built up. This leaves, for the present at least, the remaining steep portion of the curve unexplained.

The sharp rise to c is not entirely understood. The charging transient and ions accumulated in the period while the voltage is off will tend to give an initial high current but elementary considerations neglecting space charge indicate that a steady state is reached in less than 5×10^{-3} sec, while the observed time is three or four times this. We do not see any simple relationship between the breaks in the curve and the failure to pull out of the cell all of the ions present before the voltage was applied, unless there is a lack of field penetration due to the high ion concentration.

The steady state current value, at $T = 1,000$ sec, is about 45 per cent of the current in the interval $a - b$. This is in agreement with the values of the barrier potential to be expected from data indicated in Figure 2 and hence is consistent with the assumption that the conditions in the interval ab are essentially free from space charge.

Figure 5 shows a group of reciprocal current-voltage plots obtained for the same X-ray beam and different periods T_0 . The

for a succession of different potentials applied to the plates of the ionization chamber—with and without α -radiation. It is seen that for each increase in voltage, with α -rays on, the ionization current rises to a high value, then falls off, rapidly at first, to an essentially steady value in about ten minutes. As indicated, this is caused by the building up within the cell of a barrier potential. If, on the other hand, the applied potential be decreased, the ionization current drops abruptly to a low value, then gradually rises again to a considerably higher steady value in about the same ten-minute period. This second sequence results from the partial dissipation of the barrier potential set up by the higher applied voltage and consequently increases the field strength within the liquid. Finally, if the applied potential be removed and the circuit closed, the ionization chamber becomes itself a transient source of current.

It is interesting to note, also, how the space charge depends upon other factors associated with the use of a liquid ionization chamber. In Figure 2 the barrier potential is plotted against the potential actually applied to the plates of the chamber. Curves *A* show that, without α -rays, the barrier potential is proportional to—about 45 per cent of—the applied potential. That is, the barrier potential, in the steady state, makes the field strength within the liquid about half that to be expected from the applied voltage. Curves *B* show that for a definite applied voltage, the barrier potential decreases with increase in the intensity of the α -rays producing the ionization. Contrary, perhaps, to expectations, this decrease in barrier potential is due to the increased conductivity of the liquid which permits a more rapid dissipation of the space charge.

It was fairly obvious that we should reconsider the validity of computing saturation from a reciprocal plot of applied field versus current for Jaffé's theory predicts a linear relation between $1/i$ and $1/E$ when E is the actual field in the liquid as reduced by the barrier potential.

Consequently, the first step in our more recent studies (3) has been to investigate the variation of the ionization current

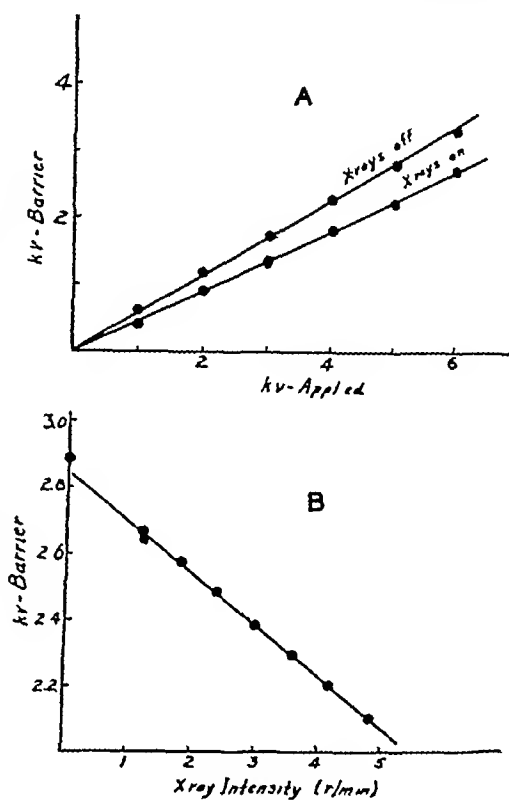


Fig 2

within that very short interval following the application of the voltage to the ionization chamber, and before the barrier potential has an opportunity to reach an appreciable value.

To do this, a square wave voltage, as shown in Figure 3-A, of variable frequency and variable amplitude was applied to the cell. The ionization current was measured during the interval *b-c*—adjustable in length and in position with respect to the front of the wave at *a*. This was accomplished by means of the apparatus indicated diagrammatically at *B*. By means of the three commutators, *A*, *B*, and *C*, the square wave voltage is applied to the ionization chamber. On the same shaft is a selector *D* which ungrounds the electrometer system for a predetermined portion of the cycle. A fifth commutator, *E*, is for the

The variation of the current at infinite field, with the intensity of the radiation, is shown in Figure 6, curves 1 and 2 being ob-

curves Potentials corresponding to the curved portion of the plots can only rarely be used in intensity comparison With

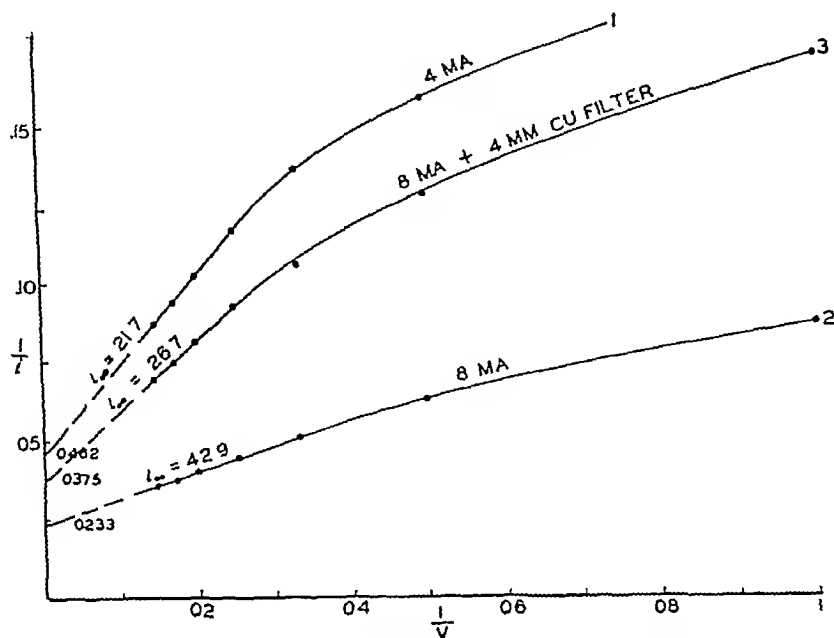


Fig 6 Inverse current voltage curves λ ray intensity varied

tained at 160 kv (constant) with 4 and 8 ma, respectively. The values of I_∞ obtained by extrapolation are 21.7 and 42.9, being within experimental limits in the ratio of 1.2. The proportionality of I_∞ to intensity has been found to hold within a range of at least 20:1 for a given quality of radiation.

When the quality of the radiation is changed at the same time as the intensity, the proportionality of I_∞ and intensity as measured by air ionization no longer holds. Curve 3, for 8 milliamperes and 0.4-millimeter copper filtration, gives a value for $I_\infty = 26.7$, making a ratio of 2.13 with the value of I_∞ at no filtration. This compares with a similar ratio of 1.61 obtained by air ionization measurements with a calibrated thimble ionization chamber.

It may be pointed out that when comparing λ -ray intensities of a given quality by means of a liquid ionization chamber, single measurements made at a given chamber potential may be used, provided they fall on the straight portions of the

direct current, applied fields in excess of 25 kv/cm must, in general, be used, while with the square wave voltage, field strengths as low as 10 kv/cm may sometimes be used.

We have thus shown how steady d.c. potential on a liquid ionization chamber can be used to determine the saturation current in a liquid exposed to x-rays.

It has been possible to evaluate the energy required to produce an ion pair in liquid CS_2 on the basis of a direct comparison of air and liquid ionization and the relative absorption of the two media. This energy is about the same for the liquid as for the gas, viz., 28 volts per ion pair. The problem of evaluating the relative number of ion pairs produced in body tissue as compared with air cannot be solved by methods developed to date because the normal conductivity of tissue is of a higher order of magnitude than the change in conductivity produced by intense radiation. We have, however, measured the ionization produced in liquids by a steady source

plots will differ, depending upon whether, $= \infty$ From the slope of the straight portion of the curve the magnitude of the bar-
for abscissæ, the applied or the effective

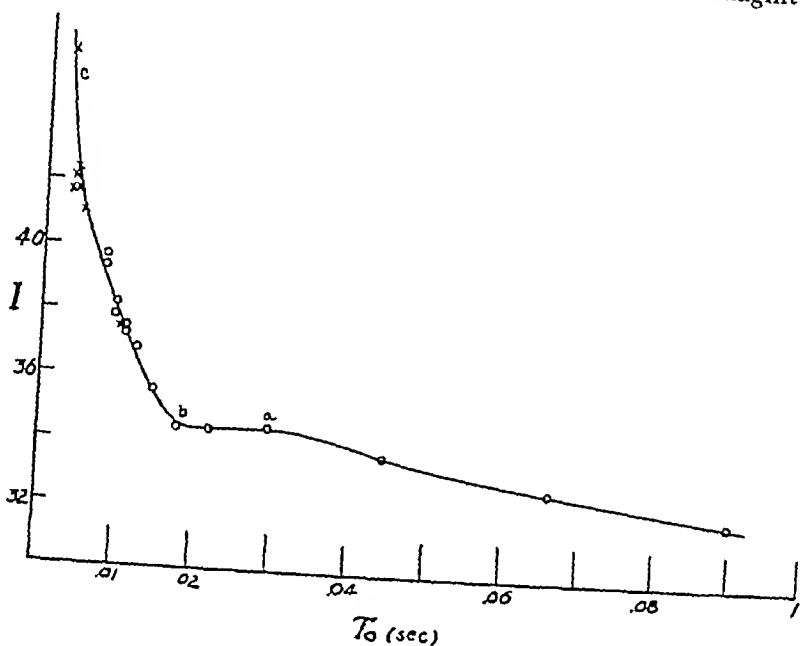


Fig 4

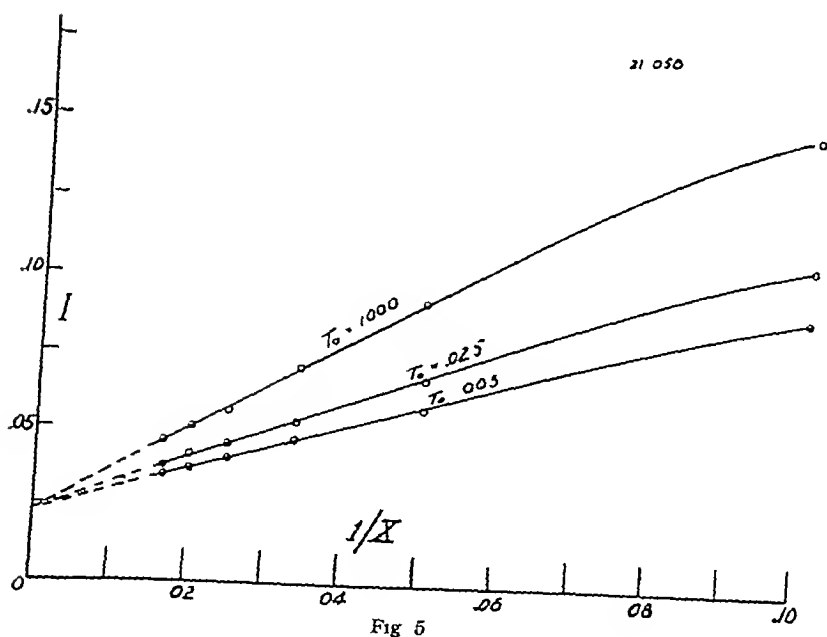


Fig 5

voltage is used. It is seen that as the interval T_0 becomes shorter, the curve drops lower. The group of curves extrapolated, appear to intersect in a single point at V

rier potential in terms of the applied potential can be deduced. These derived values have been checked for other values of T_0 ranging up to 19 minutes.

AN OIL-IMMERSED X-RAY OUTFIT FOR 500,000 VOLTS AND AN OIL-IMMERSED MULTI-SECTION X-RAY TUBE¹

By E E CHARLTON, GEORGE HOTALING, W F WESTENDORP, and
L E DEMPSTER, *Schenectady, N Y*

IN recent years there has been an ever growing demand for higher voltage x-ray equipment in both the medical and the industrial fields. An x-ray tube that must operate continuously day after day at high voltage and current requires a degree of dependability and reliability that is more

must be stable and reproducible and they must be free from occasional puncture of the insulating envelope. Operating delays caused by the necessity of prolonged aging, by instability, or by the occasional puncture of the insulating envelope, will become increasingly serious

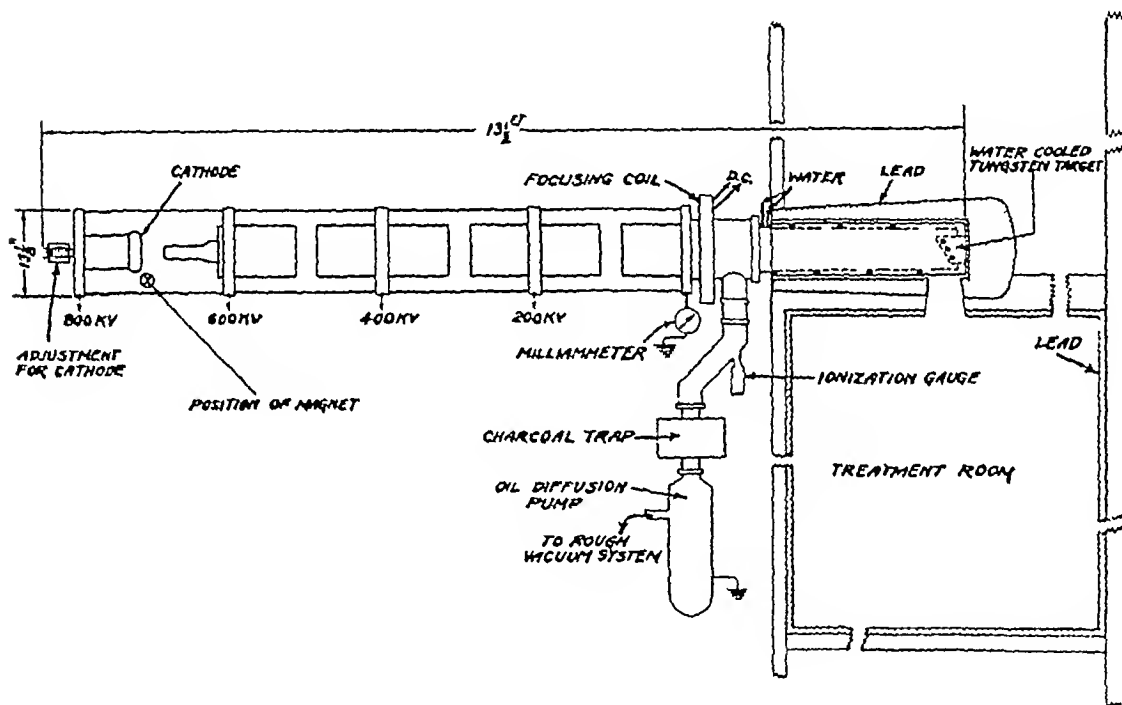


Fig 1 Four section high voltage x ray tube

exact than is needed in types of tubes designed primarily for experimental work. Such tubes must require only the minimum amount of technical service and of operating attention to be a useful tool in medical and industrial application. They should never be operated up to the very limit of their capacity, they should be capable of operation at full load within a few moments from the time the operator has applied the voltage. Their electrical characteristics

¹ Read before the Radiological Society of North America at the Twenty second Annual Meeting at Cincinnati, Ohio Nov 30-Dec 4, 1936

Field Current Problem—The field current problem is perhaps the most important limiting factor that determines the maximum voltage and current at which the tube can be safely operated. These currents are produced by electrostatic forces which are powerful enough to pull electrons out of cold metal surfaces. Field currents may cause unstable operation in any x-ray tube and may destroy the vacuum as well. The dangers of producing field currents at higher voltages may be minimized by a suitable choice of metal,

of γ -rays in instances in which the natural conductivity varied over a range of 1,000 times, and have found no measurable change in the ionization, produced by the γ -rays, arising from variations in the normal conductivity

We also reported earlier some measurements of Eve's constant by means of a liquid ionization chamber (4). These, made with 50 mg of radium and involving large and somewhat uncertain corrections, gave for Eve's constant a value of 6.9, which is considerably below the value obtained by Glasser, Mayneord, and others. These measurements have been repeated,

using 500 mg of radium. The resulting value for Eve's constant was slightly higher than our earlier value, but still substantially lower than that obtained by the other investigations. We are not yet ready, however, to put full faith in the correctness of our results.

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trodes The tube has an over-all length of 14 feet and is 13 inches in diameter, and is operated while connected to a vacuum sys-

ure 2 shows a photograph of one of these four-section tubes It is mounted on an insulating support of porcelain, treated

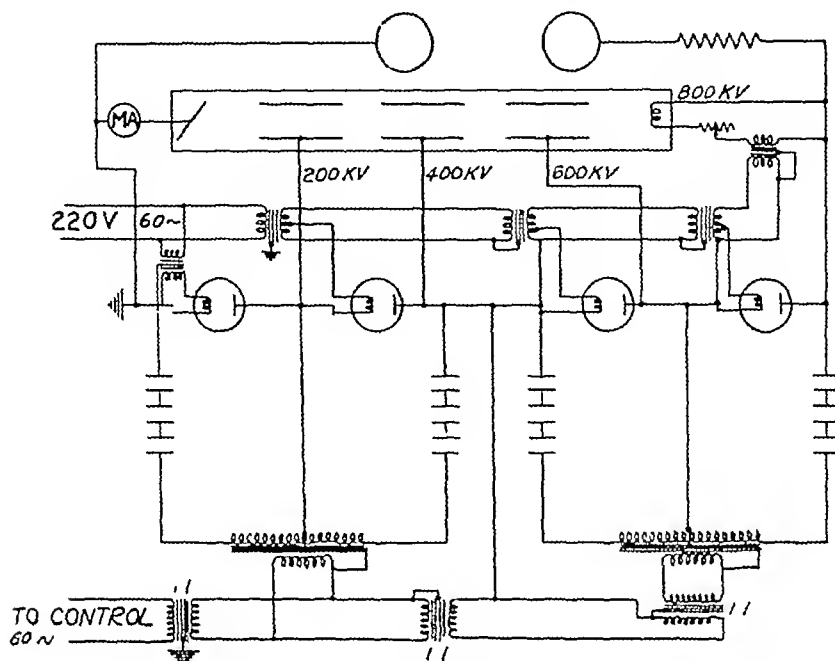


Fig 3 Eight hundred kv voltage doubling circuit

tem This is done largely because complications connected with operations on a pump do not seem to be as serious as those of thoroughly outgassing the entire tube structure in these larger types of tubes In our earlier experience with the operation of tubes on the pump it was clearly demonstrated as being desirable to eliminate the refrigerant from the trap between the tube and the pump, in commercial installations, both because of the expense and because of the exacting attention demanded The substitution of an oil diffusion, for mercury diffusion, pump made this possible Apiezon oil is used in this pump, which has been designed to operate at high speed A charcoal trap is placed in the line between the diffusion pump and the tube It improves the vacuum that can be obtained in the tube and prevents oil vapor from gaining entrance to the tube A vacuum of the order of 0.004 micron can be easily maintained in this tube with the minimum of care when it is in daily operation over a period of many months Fig-

maple, and paper shellac pillars The anode end of the tube is at ground potential Electrical conductors of large diameter are used between the intermediate electrodes and the proper taps on the high voltage generator to eliminate the corona problem

Many different types of generators could be built which would be satisfactory in supplying voltage to a tube of this design The one chosen for this tube was a voltage-doubling circuit employing several transformers, condensers, and rectifier tubes Figure 3 shows a circuit diagram and Figure 4 a photograph of this equipment It is capable of supplying 30 ma continuously at 800 kvp to the x-ray tube

Oil-immersion of X-ray Tube and Generator—An x-ray outfit of this capacity built for operation in air requires a special building to house it, which increases its cost of installation To reduce this total installation cost, we have been developing high voltage units to operate in oil Both

by its proper heat treatment before assembly and during exhaust, and by suitable electrode and tube design. The harmful

struction in order to control better the field current problem in high voltage tubes. By intermediate electrodes between the

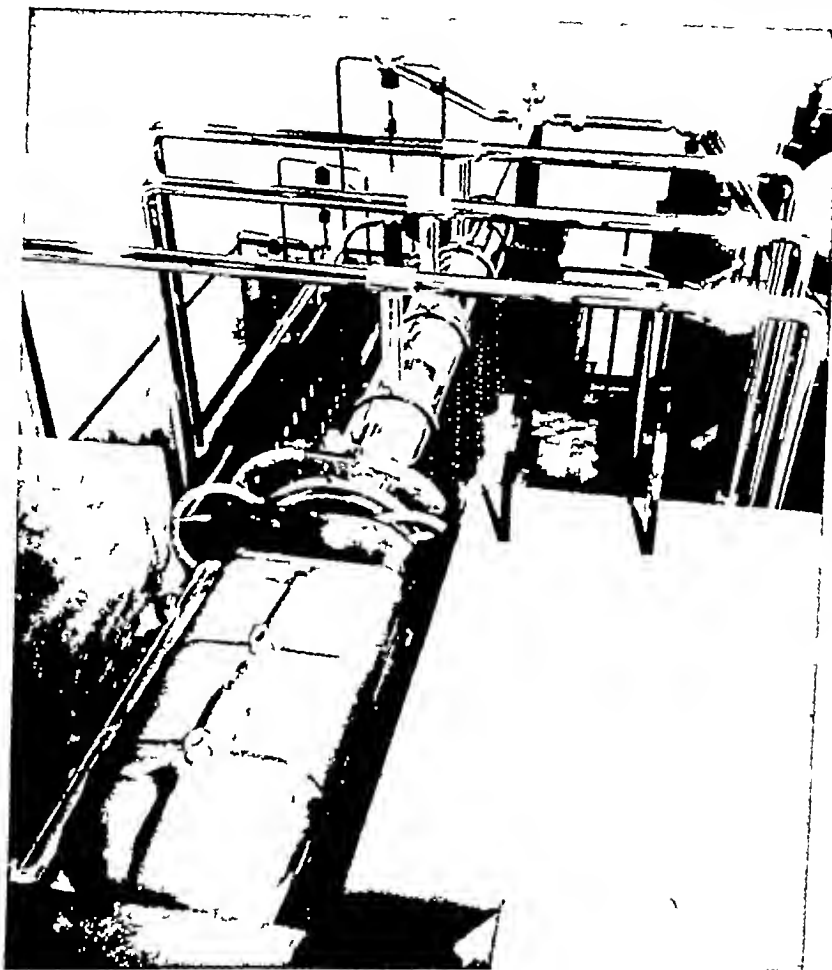


Fig 2 Eight hundred thousand volt multi section x ray tube

effects of these currents may be minimized and the voltage range may be widened by increasing the strength of the dielectric wall of the insulating envelope. This may be done by thickening the glass or porcelain wall, immersion in oil, or the use of a double wall vacuum jacket. The harmful effects of field currents may also be decreased by suitable electrode dimensions, and by electrode shielding, which decreases the chance of these random currents striking the insulating envelope.

Multi-section X-ray Tube Construction — Several years ago Dr Coolidge (1) began the development of the multi-section con-

cathode and anode the potential gradient across the tube could be better distributed. The maximum voltage between any adjacent pair of electrodes could thus be kept safely below values at which field currents might occur. We have had two tubes of this type in active operation in busy hospitals for three years, and they have been completely free from the field current problem. Figure 1 illustrates the construction of this type of tube which was built for operation in air at 800,000 volts. It consists of four sections with 200,000 volts applied to each. There are a cathode, anode, and three intermediate elec-



Fig 6

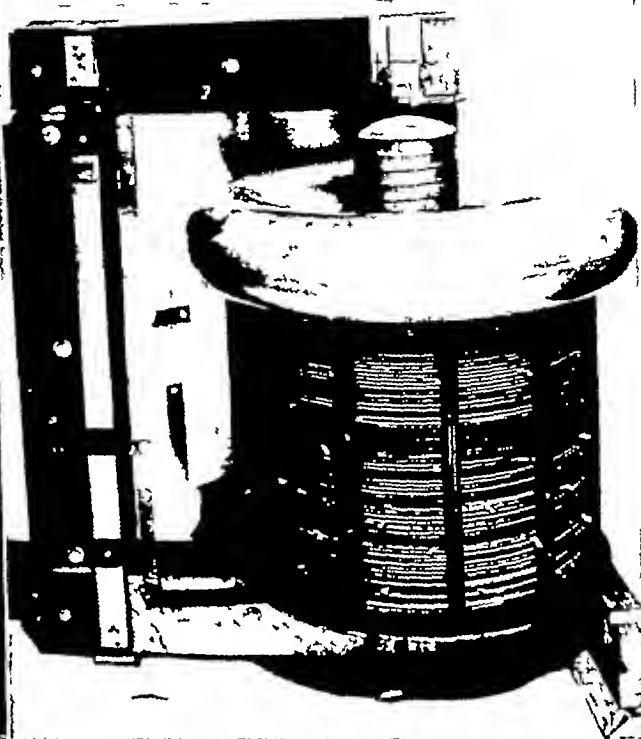


Fig 7

Fig 6 Five hundred thousand volt oil-immersed multi section x-ray tube

Fig 7 Five hundred thousand volt x ray transformer

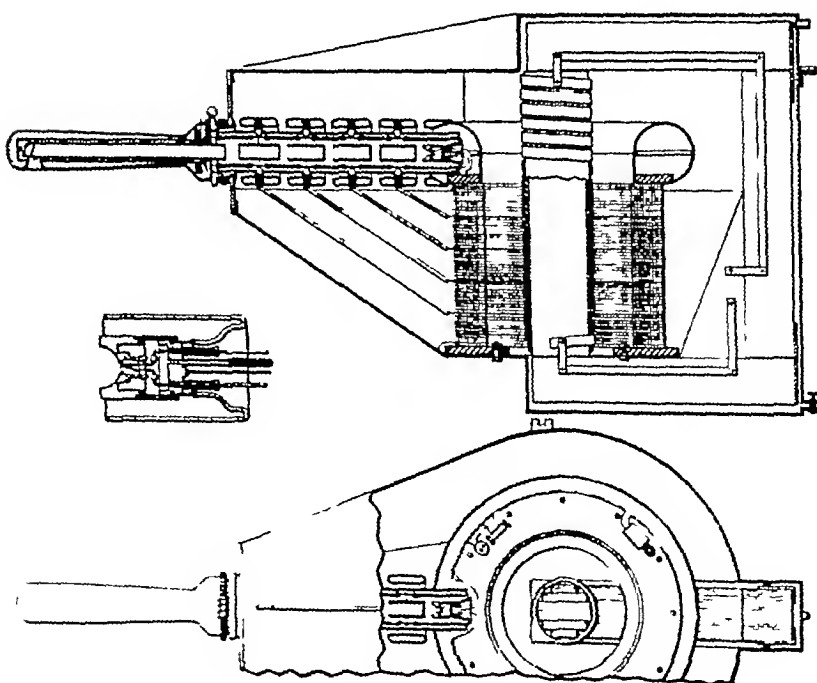
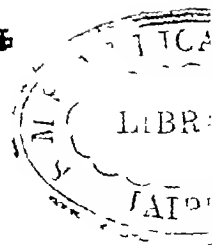


Fig 8 Cross section and top view of 500 kv oil immersed x-ray unit



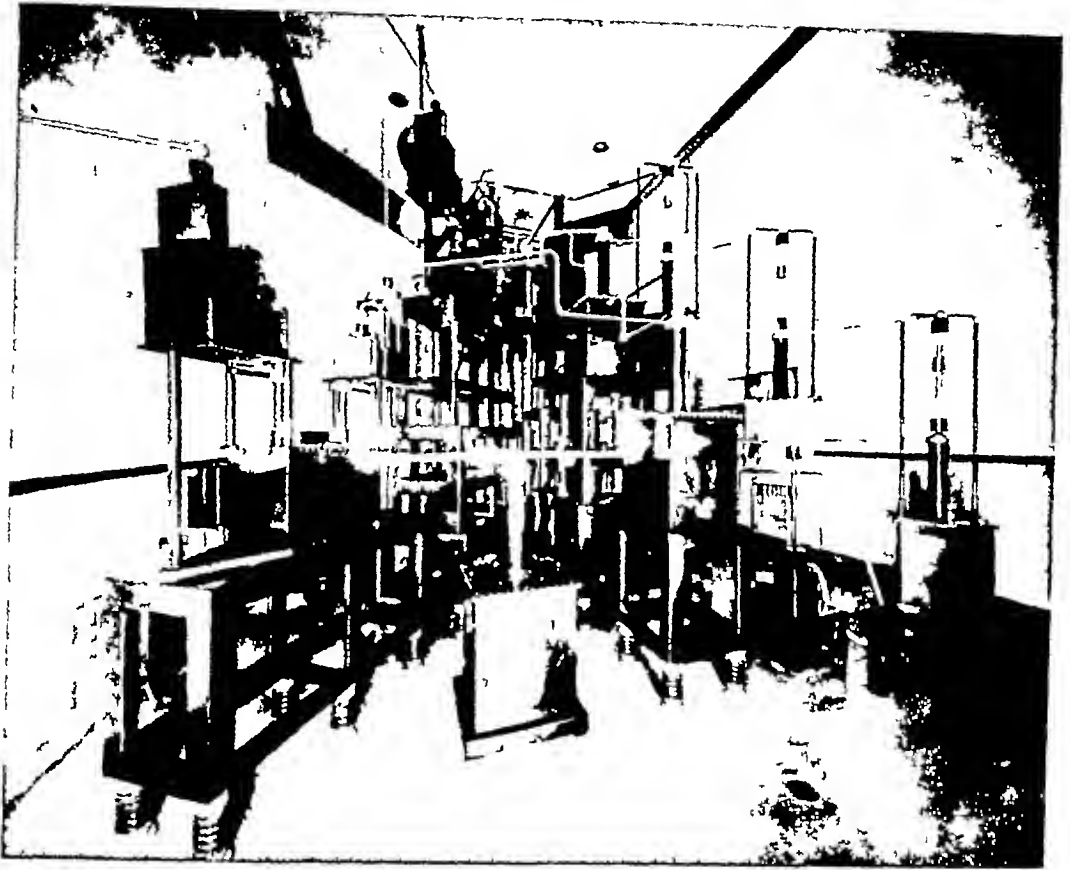


Fig 4 Eight hundred thousand volt generating apparatus

the x-ray tube and the high voltage generator will be immersed in oil, and no high tension leads will be exposed to air. The use of oil insulation greatly reduces the volume of the equipment, and the smaller installation space permits its use in practically any existing building.

Multi-section Oil-immersed X-ray Tube

The oil-immersed tube we wish particularly to describe is for operation at 500,000

volts, with the x-ray target at ground potential. Figure 5 is a diagram of the five-section tube designed for operation at this voltage in oil. The tube consists of a cathode, anode, and four intermediate electrodes. The insulating portion of the tube has an over-all length of 26 inches and a diameter of 3.5 inches. The extension chamber is built with a nickel tube 24 inches long and 2 inches in diameter.

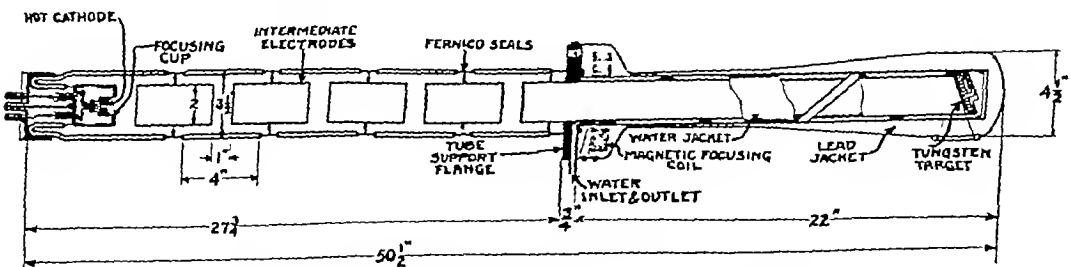


Fig 5 Five hundred thousand volt multi-section x ray tube

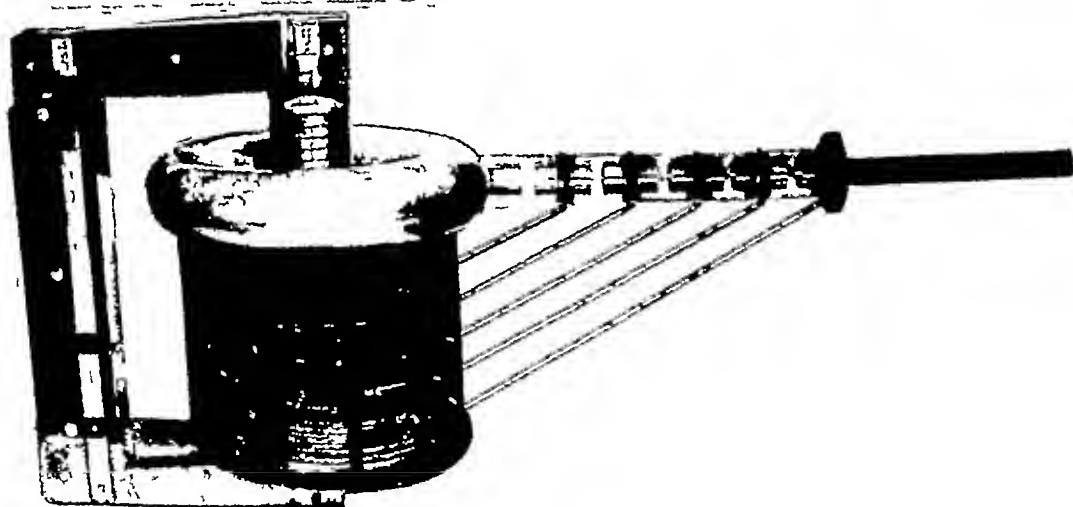
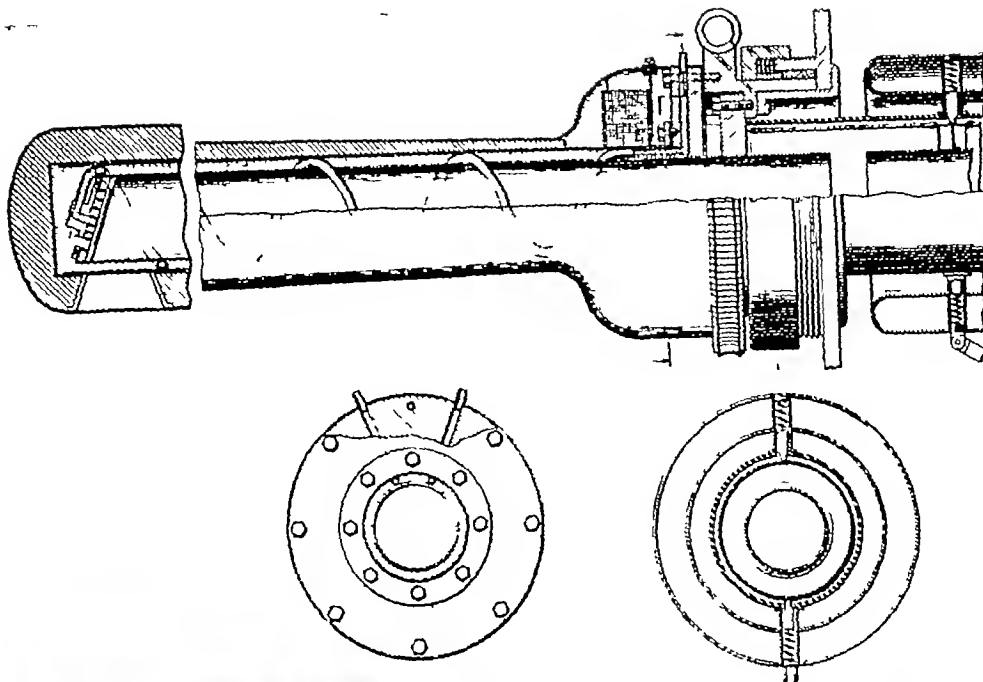


Fig 10 (upper) Anode end of revolving tube of 500 kv oil immersed x ray unit
 Fig 11 (lower) Composite photograph of x ray tube and transformer

The round center core, the bottom and top yoke, and the vertical leg are all bolted up as individual units and then assembled with thin phenolic resin spacers between them. This construction eliminates the tedious interleaving of the iron. The round core is placed in the center of the tank, while the yokes and the vertical leg are recessed in troughs along the tank

walls. In this construction the blending of these portions of the magnetic circuit into the interior of the metal container eliminates the effect of corners and edges and hence provides great electrostatic smoothness as well as materially reducing the size and weight of the entire outfit.

The primary is wound on a paper shellac cylinder placed around the round core,

The tungsten target is backed by nickel cast on in vacuum, and is located at the end of the tube outside the voltage insu-

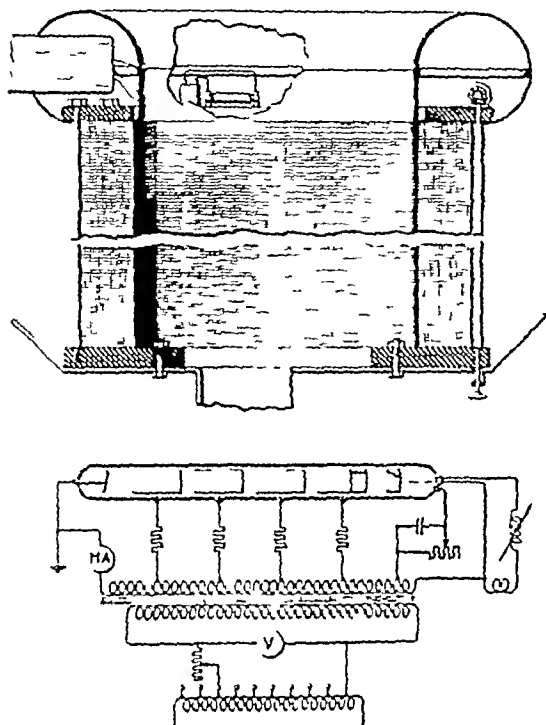


Fig 9 Secondary winding and circuit diagram of 500 kv oil immersed x ray unit

lating envelope. The intermediate electrodes are connected to the glass with Fer-nico metal seals (2). This metal is an alloy which has an expansion coefficient that exactly matches that of the glass and hence permits the metal, at the point of fusion to the glass, to be of any thickness desired to give a very rugged structure. The intermediate electrodes are hollow cylinders 2 inches in diameter and 4 inches long with their co-operating ends spaced 1 inch apart. The focusing cup surrounding the filament is electrically insulated from the filament in order that it may serve as a grid to limit the electron flow to any time interval desired. The metal flange attached to the extension chamber serves as the tube support. A demountable water jacket, for cooling the tungsten target and the side walls of the extension chamber, is fastened to this flange. A lead jacket

surrounding the extension chamber, to provide protection against all radiation except the useful beam and the portion that passes back through the axis of the tube, is also fastened to this metal flange. A magnetic focusing coil is housed inside this lead sheath to adjust the diameter of the focal spot to any desired size. Figure 6 is a photograph of one of these tubes. In comparison with the previous tube for operation in air at 800,000 volts this one is extremely small. Utilizing this principle of construction, an x-ray tube can apparently be built for satisfactory operation at any desired voltage. The diameter and length of the extension chamber housing the x-ray target are determined by the size of the focal spot and the desired location of the x-ray emitting source with respect to the patient or radiographic object.

The Oil-immersed High Voltage Generators—There are many types of high voltage generators that could be built to supply power to this tube. Most of them are complicated, requiring many pieces of electrical equipment, the construction and assembly of which make them inherently expensive. In this development we have sought to reduce cost to the minimum by having a single step-up transformer and permitting the tube to rectify its own current. This is one of the simplest forms of x-ray generating outfit. Figure 7 shows a photograph of the transformer. In the design of this unit we have attempted to emphasize simplicity, ruggedness, and reliability. The three parts of the transformer, the magnetic circuit, and the primary and secondary coils show these qualities to a marked degree.

The magnetic circuit is provided with four gaps of predetermined width. These gaps require a high magnetizing current which is automatically supplied by the charging current in the secondary winding and thus obviates the necessity of drawing a large charging current from the line. In other words, by means of the four gaps the circuit is tuned, and the primary current drawn from the line is a minimum.

high potential, eliminates the danger of gradients may be established near the high stress points developing on any of electrode surfaces, when this outfit is these parts Voltage taps are brought out operated at several hundred thousand

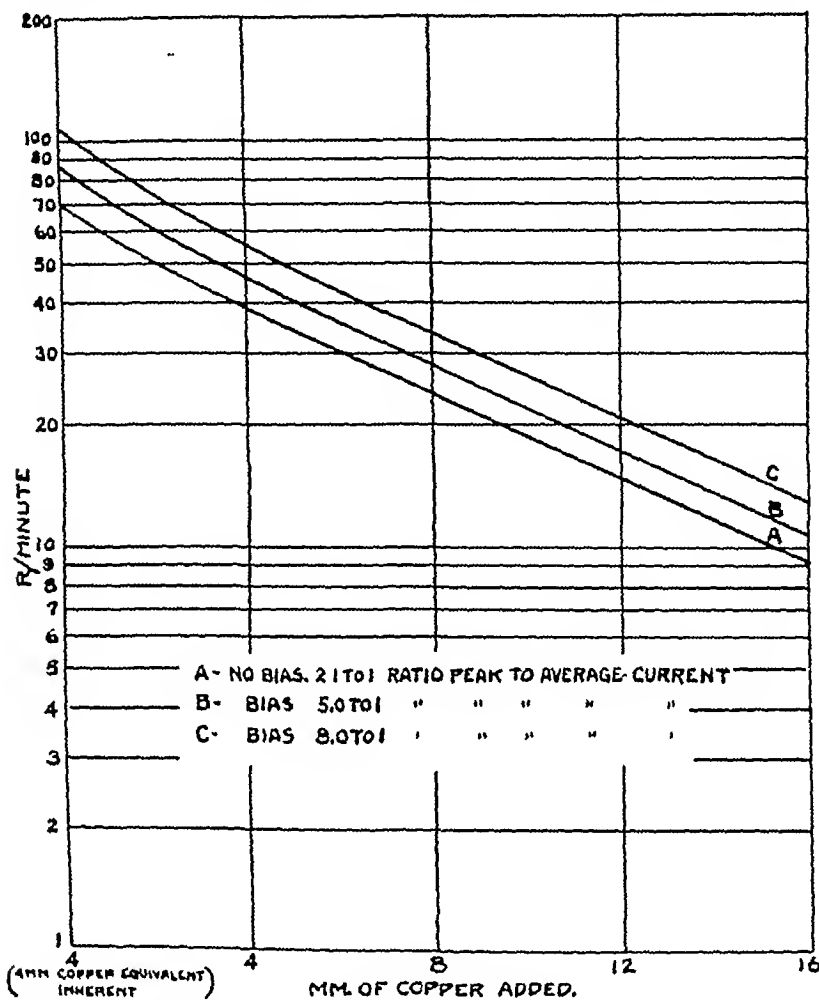


Fig 13 X-ray output of self-rectified multi section x-ray tube 525 kv p, 10 ma current 70 cm target-chamber distance no back scatter

from suitable places in the secondary winding and connected to the intermediate electrodes, through high resistances and toroidal shields which have been placed around the tube envelope. Strong radial fields would exist between the intermediate electrodes and the grounded tank walls, which become increasingly pronounced with the sections nearest the cathode. Because of the relatively small radius of curvature of the electrodes and the large difference between the dielectric constants of the vacuum within the envelope and the relatively high potential

volts. These gradients could be sufficient to produce cold cathode discharges in a radial direction and have sufficient energy to damage and possibly to puncture the envelope walls. The toroidal shields, surrounding each of the intermediate electrodes and connected to them provide effective electrostatic shielding against these radial fields within the tube envelope and eliminate the danger of disruptive discharges to the glass walls. These shields are mechanically supported by a paper-shellac tube, which surrounds the x-ray tube, and are connected by sliding spring

and consists of a helix of flat bare copper strip with cord spacing. The outside surface is very smooth electrostatically. The

vature, toroidal in shape, which serves as a housing for the cathode end of the tube, the filament winding, the filament control

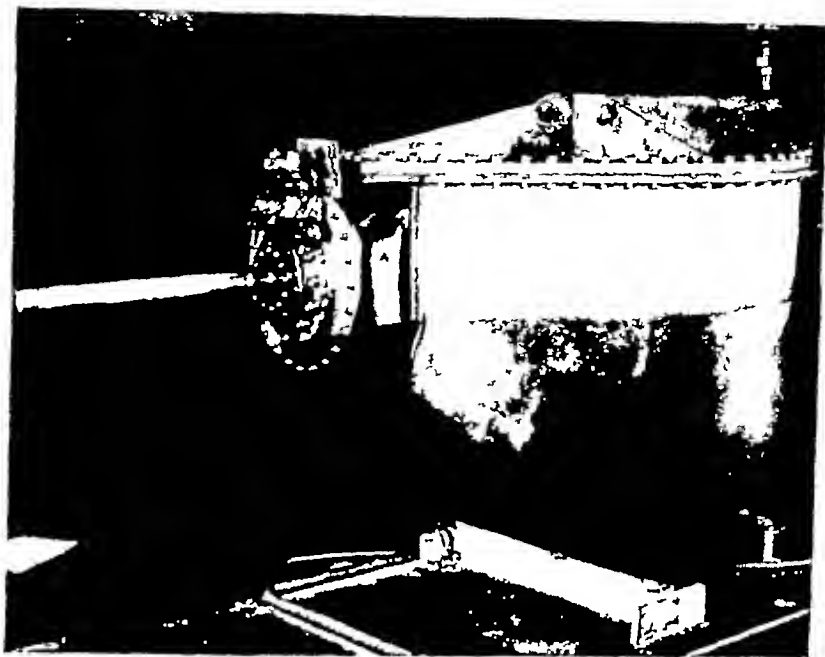


Fig. 12 Five hundred thousand volt x ray outfit

primary voltage is low and can be obtained from an autotransformer operated on the 220-volt 60-cycle line. The primary current drawn at a useful load of 525 kv p. and 10 ma. is 56 amps. at 185 volts, the power factor being about 70 per cent.

The secondary consists of 74 coils, all of the same diameter, made up of press-board rings and double cotton-covered wire baked in shellac. These coils are stacked up and held together between two insulating end rings, by means of mycalex bolts placed on the outside of the coils. This method of construction of the secondary permits a more uniform grading of the potential throughout the solid dielectric materials. As a result, the dangers of surface creepage discharges are minimized, and a higher total voltage can be safely obtained from the secondary winding of any given size. The high voltage end of the secondary is provided with an aluminum spinning of large radius of cur-

reactor, and the bias elements. The minimum distance between primary and secondary and between the aluminum spinning and the tank is five inches.

The Assembled Oil-immersed Outfit—Figure 8 shows the plan of the assembled unit. The over-all dimensions of the tank are 4 feet wide, 4 feet high, and 6 feet long, which includes the projected cone housing the insulation portion of the x-ray tube. The tube is fastened to the grounded metal tank by the anode flange, and thus serves also as the main tube support. The transformer is bolted to the bottom of the tank. The cathode end of the x-ray tube recesses into the aluminum spinning, and is electrically connected to the filament energizing circuit and the cathode biasing unit, all of which are housed inside this electrostatically shielded structure. This use of the aluminum spinning as a housing for this auxiliary equipment, which must necessarily be at

cup positive in potential with respect to the filament during that portion of the cycle at which current flow is desired

oscillographic record of the part of the voltage wave at which current was flowing when the above x-ray measurements were

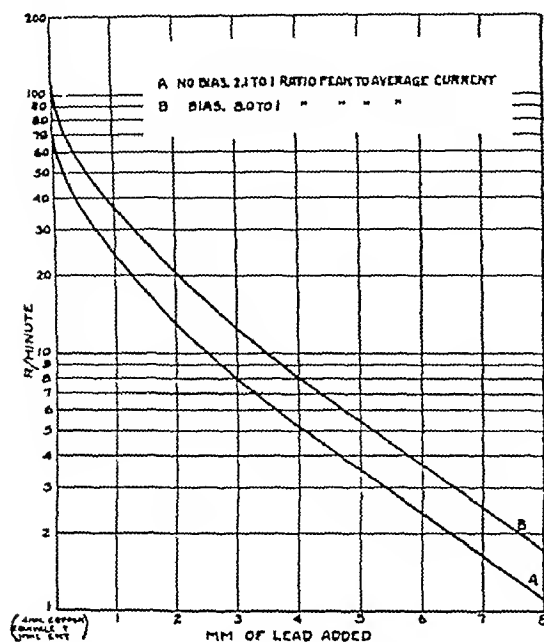


Fig 15 (left) X ray output of self rectified multi section x-ray tube 525 kVp, 10 ma current 70 cm target-chamber distance no back scatter

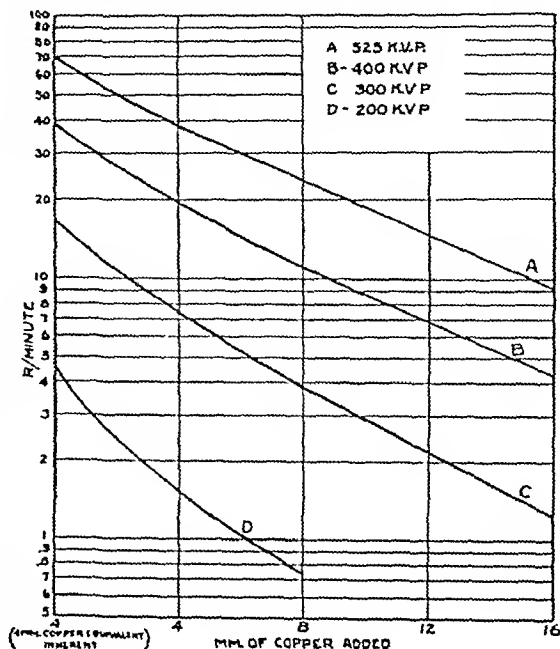


Fig 16 (right) X ray output of self rectified multi section x-ray tube 10 ma current, no bias 70 cm target chamber distance no back scatter

This is accomplished by connecting the focusing cup to a tap on the main winding which provides a positive potential during the useful half cycle to the focusing cup and by offsetting this positive potential by a constant negative bias due to a charge accumulated on a condenser placed in the lead between focusing cup and tap (Fig 9). The magnitude of this negative bias may be regulated by a control resistance connected across the condenser which allows the charge to leak off, and thereby determines the desired amount of bias.

X-ray Output—Figure 13 shows the copper absorption curve for different degrees of bias. These measurements of the x-ray beam were made at 90° to the main axis of the tube and with a standard Victoreen condenser r meter. It is to be noticed that at these higher voltages the quality of the radiation is practically independent of the amount of bias that is used on the cathode. Figure 14 shows the

made. The use of bias in these higher voltage tubes will increase the total x-ray output per milliamper, but will not affect the quality of the beam after it has passed through the inherent filtration of the tube envelope which is equivalent to four millimeters of copper. Figure 15 shows the lead absorption curves for different degrees of bias. The quality of the radiation is the same in both cases. Figure 16 gives the copper absorption curves with the unit operating at different voltages and without cathode bias.

This 500,000 volt unit is shock-proof, semi-portable, and does not require a special building to house it. The accessibility of the x-ray target operating at ground potential simplifies the problem of providing adequate x-ray protection by allowing it to be placed nearer the generating source, and permits the use of tap water for cooling the target. Our experience with this equipment indicates that we

contacts with the intermediate electrodes. In order to permit rotation of the useful beam of x-rays around the long axis of the

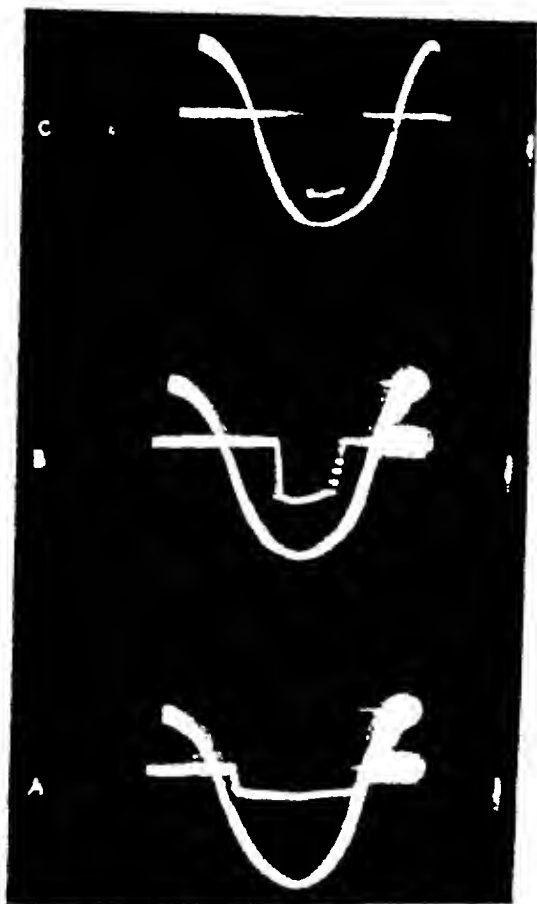


Fig. 14. Cathode ray oscillograms showing voltage and tube currents. (A) Bias 2.1 to 1 ratio peak to average current, (B) bias 5.0 to 1 ratio peak to average current, (C) bias 3.0 to 1 ratio peak to average current.

tube, the entire tube is rotatable independently of the tank by means of a gear wheel mechanism. Essentially the construction includes two bearing surfaces with a suitable oil-tight packing joint. Sufficient flexibility is given the cathode connections to permit 360 degrees of rotation of the x-ray beam around the long axis of the tube. We contemplate rotating the unit as a whole in the vertical plane through the tube, by mounting suitable trunnion supports on the two sides near the center of gravity of the outfit.

Figure 9 illustrates better the method of filament control. An insulated drive

shaft, positioned close to the secondary coil, extends from the bottom of the tank up into the aluminum spinning, and the inductance or resistance, used to control the filament heating current and thereby the amount of electron current from the filament can be adjusted, so that the current and voltage of the x-ray tube can be independently chosen. In a similar manner the amount of bias on the x-ray tube can be adjusted. The electrical circuit diagram is also shown in Figure 9. The milliamperemeter is placed between the low voltage end of the secondary winding of the transformer and ground, and a voltmeter, placed across the primary, is calibrated to give the kilovoltage applied to the x-ray tube. A pick-up plate may be placed inside the tank and connected to a cathode-ray oscillograph, which can then be calibrated to indicate directly the kilovoltage, the wave form, and the relation between the inverse and useful voltages. The inverse and useful voltages are very nearly equal due to the low reactance of the transformer. Figure 10 shows more in detail the construction of the x-ray target projecting from the tank wall.

Figure 11 is a composite photograph of the transformer and x-ray tube without the shields, outside the tank. Figure 12 shows the assembled outfit in the tank. This outfit has been operated experimentally up to 700,000 volts and 10 ma and can be very conservatively rated at 500,000 volts and 10 ma for continuous operation. There are no inherent difficulties in increasing the current capacity of this unit if a more intense x-ray output seems advantageous.

The Use of Cathode Bias—The use of a negative bias between the focusing cup and the filament permits electron flow throughout that portion of the voltage wave that is desired. This allows the generation of x-rays to occur only near the peak in the voltage wave, and increases the x-ray output per milliamperemeter so that it closely approximates that of a constant potential generator operating at the same voltage. The bias circuit used renders the focusing

THE THIMBLE IONIZATION CHAMBER¹

By OTTO GLASSER, PH D, and JOHN VICTOREEN, *Cleveland, Ohio*

IN 1925, Fricke and Glasser (1) constructed small thimble chambers of many different materials and shapes in an attempt to test a theoretical formula by means of which the ionization current within the thimble chamber could be cal-

culated by the previously mentioned formula. Investigations which we have carried out over a number of years have supported this contention. Curve A in Figure 1 represents a previously published (3) curve of the ratio of ionization currents

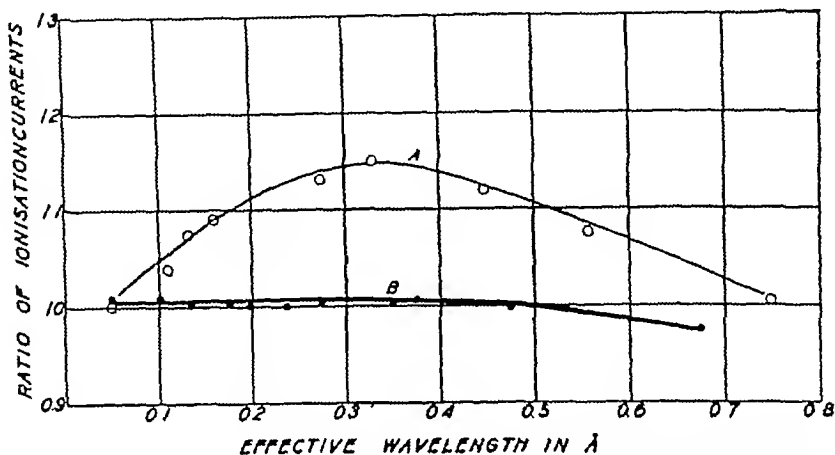


Fig 1 Ratio of ionization currents for thimble chambers and a standard air chamber for various wave lengths A Fricke Glasser "air wall" chamber B Special bakelite chamber

culated with sufficient accuracy to be used as a primary standard for roentgen-ray quantity. In this attempt they were not entirely successful. Although much valuable information regarding the behavior of various thimble chambers was obtained, the so-called "air wall" chamber of carbon and aluminum, calculated according to the Fricke-Glasser formula to have the same effective atomic number as atmospheric air (7.69), failed to agree with the standard air ionization chamber. However, this disagreement stimulated extensive studies on the problem of "air wall" chambers. H. T. Meyer (2) was the first to call attention to the fact that thimble chambers which were made to agree with the readings of a standard air chamber had an effective atomic number which was lower than that

in the Fricke-Glasser "air wall" chamber to those of the standard air chamber for various effective wave lengths. Curve B shows the same ratio for a thimble chamber built to produce ionization currents which run parallel to those in the standard chamber and which, for a given volume of 2.48 cc, had a bakelite wall with an effective atomic number of 6.32. Other investigators, notably Albrecht (4), Friedrich, Zimmer, and Schulze (5), Glocker and Kaupp (6), Küstner (7), Mayneord (8), Meyer (2), Miehlnickel (9), Murdoch and Stahel (10), and Sievert (11), have investigated further the factors which contribute to the ionization within the enclosing walls of a thimble chamber and although their results as a whole are similar to those of Fricke and Glasser, their studies have brought out some new points of importance. It is the purpose of this paper and of others which are

¹ Presented before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati, Nov. 30-Dec. 4, 1936.

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can build other oil-immersed units for much higher voltages with this same general design, without increasing their volume and weight to excessive proportions or requiring the construction of special buildings in which to install them

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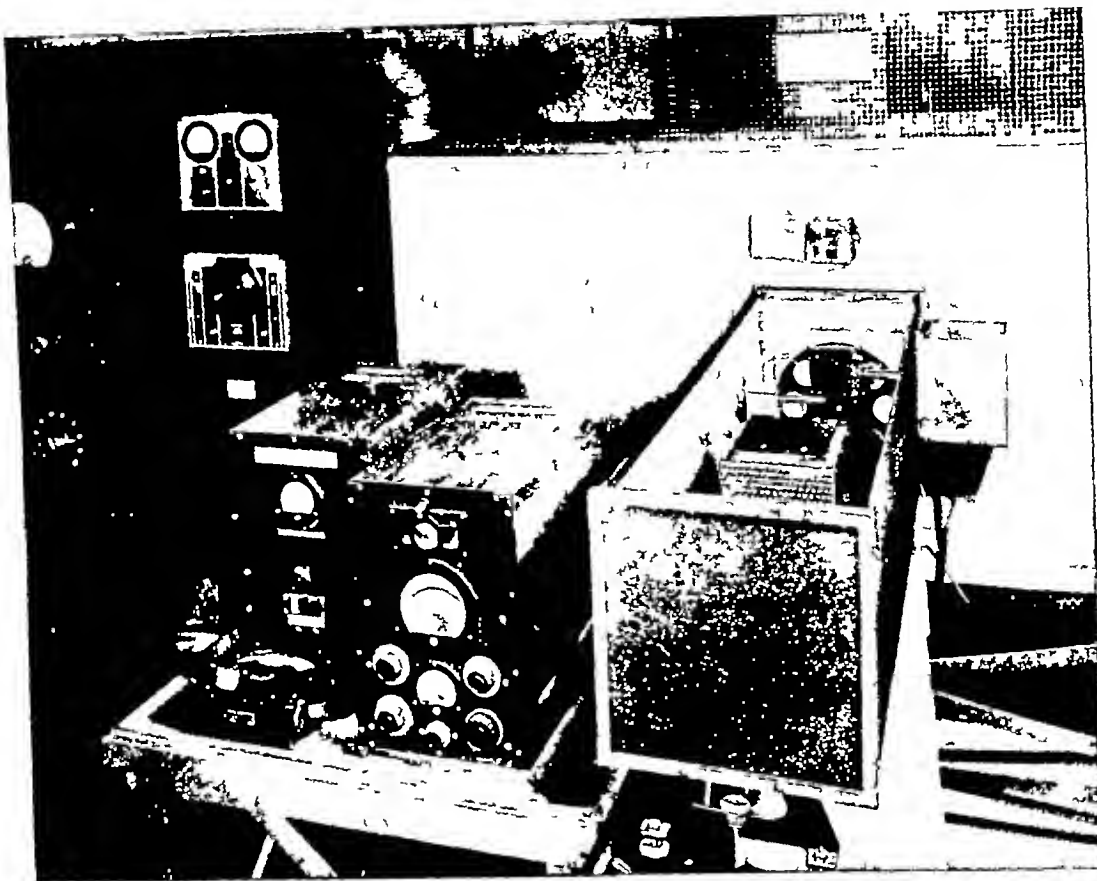


Fig 4 Ionization chamber measuring arrangement

which causes the major portion of the ionization current at wave lengths less than about 0.10 \AA

In a thimble chamber the electric field required to prevent recombination of the ions formed exists only in the air volume of the chamber and terminates at the inner boundary of the chamber wall, therefore, even though the process of ionization within the wall material is similar to that within the air volume, only the ions formed within the air are collected

The ionization current within the chamber is increased only by the ions formed by those electrons which are directed from the wall into the air volume or by scattering of photons into the air volume. It is evident from this mechanism that the radiation incident to the outside of the chamber must lose energy in the wall before reaching the air volume inside, and that the loss is dependent on the absorp-

tion in the wall, and therefore, dependent upon its thickness and probably its density. From this fact alone one would expect the ionization current in a given chamber to decrease as the wall thickness is increased. On the contrary, Albrecht (4), Mayneord (8), and Friedrich (5) have shown that in the gamma rays there is an increase in current with increasing wall thickness up to several millimeters. We have examined chambers of graphite, bakelite, and aluminum to determine the effect of these substances, and our results are in substantial agreement with those obtained with gamma rays by the authors just mentioned (See radium curve in Figure 2)

For roentgen rays of effective wave lengths of 0.283 \AA and 0.105 \AA , as shown in Figure 2, and even up to about 0.05 \AA as produced with voltages around 600 kv, we find no substantial change in current with

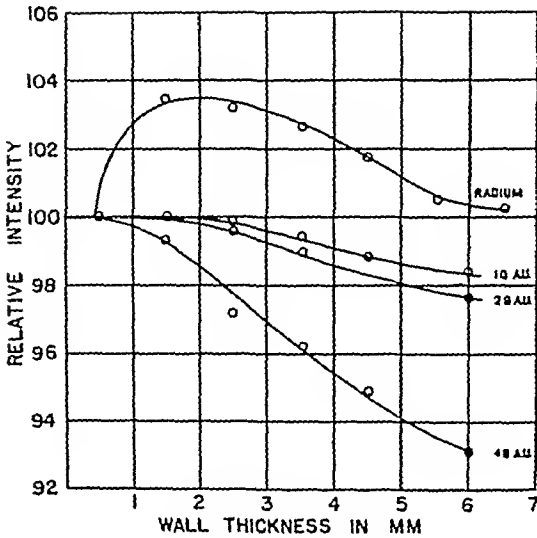


Fig 2 Influence of wall thickness of bakelite thimble chamber upon ionization current. Top curve for radium filtered with 1 mm Pt at large distance. Lower curves for three roentgen ray beams of 0.105 Å, 0.283 Å, and 0.48 Å effective wave lengths.

to follow to correlate those observations with our own.

As a rule, better calculated agreement is obtained between the thimble chambers of

different materials, provided the materials are absolutely pure, than between chambers of different volumes and shapes. The effects of different wall areas and thicknesses and, in addition, the effects of the total volume of the chamber or the diameter upon the ionization produced within are complicated and therefore difficult to predict. A consideration of the mechanism of absorption and an actual study of the various effects which result in the production of ions will illustrate this point.

In the process of absorption, a photo-electron is ejected by an impacting photon, the photo-electron absorbing the full energy of the photon. The photo-electron, in turn, loses its kinetic energy in forming ions along its path of travel. This is the true photo-electric absorption which constitutes the major part of ion production for longer wave lengths. If the impact of the photon is not direct, only a part of the photon energy is absorbed, and the directions of travel of both the impacted electron and the photon are changed, the recoil electron gaining the energy lost by the photon. This is the type of absorption

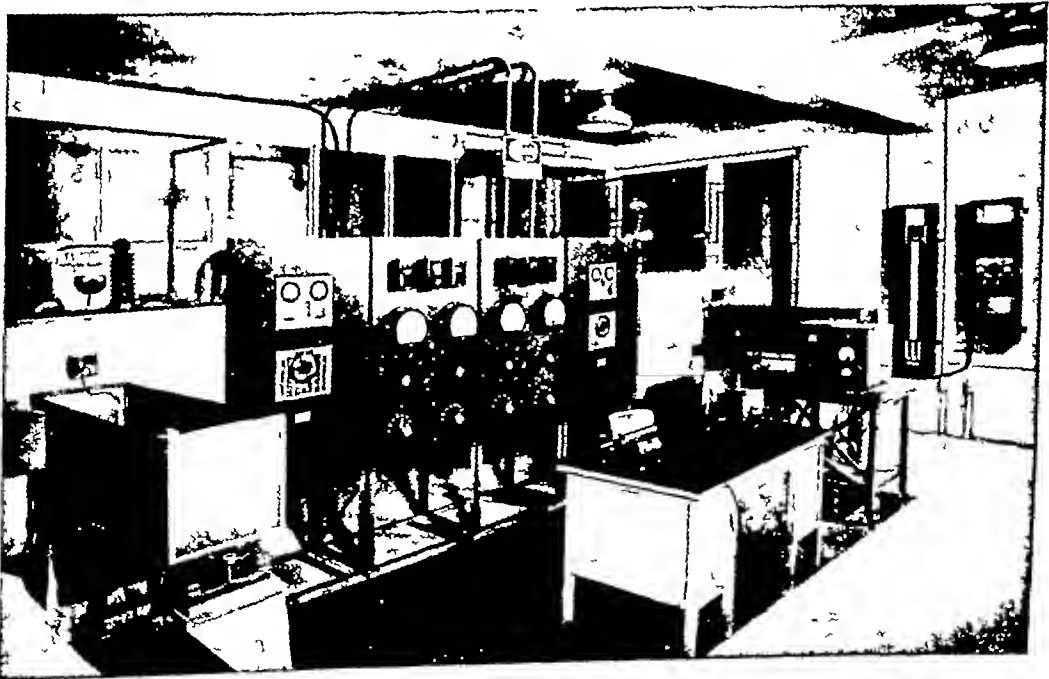


Fig 3 Roentgen ray machines and controls

in a complete study of the measurement of roentgen-ray quantities in roentgens for all wave lengths in the x-ray and gamma-ray regions (13). As a practical result of these investigations, we might again state here that the value of 8.8 roentgens per milligram element hour at 1 cm distance, as published by Glasser and Mautz (12), in 1929, and since then confirmed by many authors, is proved correct according to these newer studies. However, these same studies also show that the calculation of this same value from the Eve's number which was recommended by various authors must be approached with great caution.

SUMMARY

In conclusion we interpret the data at hand at the present time as follows:

1. The Fricke-Glasser limitation of the air equivalence of a thimble chamber to the wall material of the chamber to satisfy the definition of the roentgen is not entirely sufficient.

2. In addition to the proper selection of the wall material, the wall thickness and the volume of the chamber must be considered.

We acknowledge with appreciation the assistance of Mr I. E. Beasley and Mr L. W. Fraser.

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DISCUSSION OF SYMPOSIUM ON PHYSICS

KENNETH E. CORRIGAN, Ph.D. (Detroit, Mich.) The part of a discussor of a paper such as the very, very fine one we have just heard by Professor Lawrence [page 313] is not an easy one. After all, Professor Lawrence is unquestionably the leader in this field and I really have nothing to discuss.

The matter of ionization by these new particles is, of course, of the most extreme interest to us all from three points of view. First of all, we must learn to measure these new radiations accurately. Up to this time the most practical method of measuring these radiations in the laboratory has been to expose to the beam a small piece of metal and then take the piece of metal and run just as fast as you can to some re-

wall thicknesses up to six millimeters. For roentgen rays longer than 0.3 \AA the current decreases with increasing wall

within a chamber will depend to a large extent upon the shape and area of the surrounding wall, in other words, the current



Fig 5 Thimble ionization chambers and shells

thickness. These measurements were made on two x-ray equipments, the outputs of which were kept constant within 0.5 per cent. The effective wave lengths were determined according to known methods on strongly fore-filtered beams. The actual intensity of the beams was constantly controlled by a standard air chamber. The set-up of the x-ray machines and the actual method of making the measurement is shown in Figures 3 and 4.

Figure 5 shows the ionization chambers used and the shells employed to increase the wall thickness in the measurements just described.

From these results, it would seem that the loss of energy caused by the increased wall thickness within the air volume of the thimble chamber is almost entirely compensated for by the scattering of photons and electrons into the air volume. In the region of the harder rays, there is an over-compensation due to the predominance of scattering and, therefore, an increased ionization within the chamber. Above 0.3 \AA , the larger part of the absorption is photo-electric, and therefore, insufficient scattering is responsible for a decrease in ionization.

Since the number of ions formed by a fast moving electron is proportional to its path through the ionizable medium, and as the number of fast moving electrons present in the ionizable medium depends to a large extent upon the number of electrons existing in the surrounding material, we may assume that the current produced

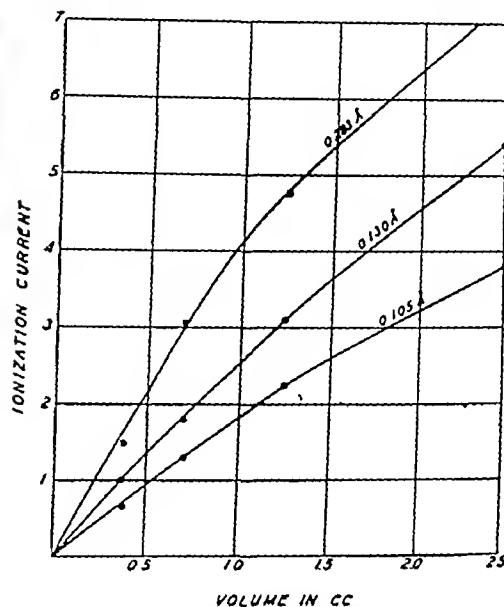


Fig 6 Ionization currents in aluminum chambers of various volumes for roentgen rays of 0.105 \AA , 0.130 \AA , and 0.283 \AA effective wave lengths.

will not increase linearly with the enclosed volume. This point, which was not clearly recognized in the original publication of Fricke and Glasser in 1925 (1), was tested carefully with a series of similarly shaped chambers but with varying volumes and varying diameters. We selected aluminum as the wall material for these chambers since it could be obtained in pure form, thus facilitating duplication, moreover, a greater current and therefore greater accuracy in measuring the current produced in the smallest chambers was obtainable. Three curves in Figure 6 demonstrate that there is no linear proportionality between the ionization current within the enclosed volume of a thimble chamber and the volume itself provided the chamber is smaller than 1 cc.

Through these investigations we have corroborated in part the findings of others and have also revealed further information on the behavior of "air wall" thimble chambers. We hope to incorporate this

describing the radiation in materials other than air because it is air that is specifically mentioned in our definitions

Well, I don't think we should take those objections too seriously. There is scarcely a unit in the whole of physical measurements that we are not called upon at some time or other to use under conditions which are very different from those which we use for standardization purposes, that we are not called upon to use under conditions in which direct use of the standard is practically impossible. Atomic physics provides many examples of just that.

It is difficult, of course, to determine quality and quantity of radiation in other materials beside air, but it is not true that a description in these units is meaningless. Quantity and quality are properties of the radiation. They are altered, of course, in traversing material, but they are not properties of the material that they are penetrating.

Quality and quantity of the radiation are not the only factors that determine the effects produced in a material. We must also consider how the beta rays and the ions they produce behave. For example, the density of the ionization produced just below the surface of a particular material by a particular quantity and quality of radiation is not equal to the density of ionization produced by the same quantity and quality of radiation somewhere in the bulk of that material. Near the surface the equilibrium in the exchange of beta rays between the materials on either side of it produces a different ionization from that in the bulk of the material.

That is shown very clearly in Dr Failla's measurements with the ionization chamber having a covering of, I think it is, chiffon—a material very readily penetrated by the beta rays. Those measurements are, of course, measurements of ionization density; they are not explicitly the evaluation of the quantity in roentgens.

Thus, measurements of the density and distribution, length of life and behavior of the ions, do not give us information that we need to use in calculating the quantity

and quality of the radiation in the particular material. It is *additional* information which is useful to us in calculating or predicting, and correlating the effects that are produced.

The action of the ions in the biologic tissue would appear to be of a catalytic nature. I do not think we can consider it as directly injuring the cells mechanically or thermally, even accepting Wykoff's hypothesis that there is a particular part of the cell that is extremely sensitive, because even there the energy available is far too small to produce direct mechanical injury. Rather, it would seem that the presence of the ions initiates and maintains biochemical reactions which continue until some other factor stops them.

For this reason these experiments on the effect of the ions produced by the radiation are of great importance to enable the biochemist to proceed in investigating the processes in the tissue which lead ultimately to the death of the malignant cells.

DR R. R. NEWELL (San Francisco) It seems to me that we are standing now nearly where we were a long time ago before the Stockholm meeting of the International Congress. In those days we had a way to measure with a small ionization chamber something or other which we called by different names. And then we found the way to measure x-rays in an open beam in the air in absolute units, define them in absolute units, and tie them in with all other physical measurements. And we felt that we had reached an absolute measurement of x-ray in the open beam.

We are still in that fix in regard to tissue ionization measurement, that we can measure *something* with a small ionization chamber and we can call it a roentgen, if we will, but it isn't a roentgen. A roentgen amounts to counting two billion pairs of ions in a cubic centimeter of atmospheric air. When we measure 100 roentgens in the beam and then put the beam on the patient, we measure with the same instrument, say 140—they are not

mote point where you have a Geiger counter set up, upon measuring the radioactivity of the piece of metal, you try to figure out what the activity of the deutron beam was

We, of course, are all trying to make some experiments measuring these radiations with chambers, and in this Dr Lawrence is far ahead of anyone else

The second thing of importance, as Dr Lawrence has said, is the matter of protection. All of us, even those who have had only a very, very weak source of neutrons up to this time, have been thinking about that and wondering what the source was going to do to us

Last of all, after we have those two fundamental problems solved, is the question of what we can do with them for the benefit of those requiring treatment

The experiments that Dr Lawrence has carried out are certainly as complete as they can possibly be up to this time and he is to be greatly commended upon his wide choice of biologic materials in which these measurements were made

There is no point in my speaking further of ratios about which he has told you. No one else has anything at all to offer you on this subject. He is far ahead of the rest of the world

DR R R NEWELL (San Francisco) A year ago, in considering neutron rays, I expressed a skepticism as to whether they would prove useful for cancer therapy. Since that time, Professor Lawrence has developed and has now presented these evidences that when one uses the biologic effects of x-ray as a datum, there is a differential action between one biologic object and another. For neutron rays it can be hoped that this differential may, under some circumstances, be in favor of the cancer therapist

Professor Lawrence proposes to go ahead now and prepare to try it out on patients who are suffering from cancer. I think we can only look with the greatest interest and with the utmost hope that he may find a differential in our favor

ERNEST O LAWRENCE, Ph D (closing) I am sorry I didn't bring this matter out clearly. We use the mice, as a whole, so to speak, as a measure of skin dosage. Roentgenologists speak a good deal of the skin erythema dose but it is equally important—and you will all agree—to consider the effect on the intestinal mucosa and other effects on the inside

Through several ports one can injure a person, certainly, by giving too much radiation on the interior. One is interested in the total tolerable amount of radiation in a part of the body where the tumor is the host and one wants to know the healthy tissue tolerance in relation to the effect on the tumor. To get a measure of the lethal action or the effect of the neutron rays on the healthy tissue, we took the whole mouse. The whole mouse includes his most sensitive parts—the skin and all his insides and everything

We find that to kill a mouse, it takes 1 over 3 S, i.e., it takes about one-fourth the dose of neutrons that it takes of x-rays to kill the whole mouse, but only one-fifth the dose to kill the tumor. So there is a differential there of about five to four. In other words, when compared to x-rays, the experiments indicate a greater selective action of neutrons on tumors in the ratio of about five to four

GEORGE C LAURENCE, Ph D (Ottawa, Canada) It gives me considerable pleasure to open the discussion on Dr Taylor's paper [page 323], for I regard these investigations as the first spade work in a very fertile field—a field of research that is of particular interest to radiological physicists because it will extend our knowledge of the relation between the bare physical description of radiation and the effects that are produced by the radiation

We have established a unit of quantity, the roentgen, and of quality, the millimeter of copper, and in setting up our standards we have specifically named the substance air as an essential part of our standards. There has recently been some suggestion that it is not logical to use these units in

like to give it, figuring a 5 per cent loss. We changed our rate of loss to 10 per cent for 200 kv radiation filtered by 0.5 mm of copper plus 1 mm of aluminum, and also changed our saturation dose from 800 to 1,000 r (in air).

At present, we give radiation to multiple fields of approximately 150 to 200 r to each field every other day when treating pelvic lesions, building our total saturation dose to 1,000 r in from a week to twelve days, and giving a total tumor or skin dose of 2,500 r within about four weeks' time. The rate and the total quantity of radiation given any pelvic lesion will depend upon the physical condition of the patient.

A constant fractionation of from 200 to 300 r is given to oral lesions without stopping at any saturation dose. However, again, multiple fields are treated at the same sitting, giving a smaller number of roentgens to each area.

We have compared the saturation technique, as used to-day, with the method described by Dr Coutard of treating carcinoma of the cervix, as given in his last paper. Dr Coutard gave his dosages in roentgens, measured with back-scattering. Considering 30 per cent back-scattering as an approximation, we figured that the rate we gave our radiation was comparable in daily dose, time, and total dose to that given by Dr Coutard.

KENNETH E. CORRIGAN, Ph D (Detroit, Mich.) I would like to compliment Mrs. Quimby on a very fine piece of work and to say that I feel this is a definite step forward for all of us. [See page 305.]

Most of these saturation techniques that we have been fooling with in the past were actually attempts to apply merely the equation of compound interest to a biologic system to which it actually had no application whatever, and although a physicist can be trusted to tell the color of the skin, I always try to avoid any question of erythema dose or any subject that would indicate that I am discussing a clinical question.

However, so far as skin coloration in

itself and alone is concerned, we have all seen applications of this saturation technique which never hatched out, and the use of a definite, carefully worked out biologic system rather than this rather amateur use of the law of compound interest at some arbitrary rate such as 5, 7, or 10 per cent, is in itself a great advancement.

It is also worth while to note that Mrs. Quimby included some mention of the difference in dosage rates. With high voltage tubes we have already shown definitely that a very different result is obtained at 53 r per minute than that obtained at 20 r per minute. I think nearly every one has found it desirable to drop down to a reasonably low r per minute output and to keep this output at high voltage the same as our rate at 200 kv, at least for the time being until we learn more about it.

EDITH H. QUIMBY, M A (closing) I wish to thank Dr. Weatherwax and Dr. Corrigan for their courtesy in discussing our paper.

With regard to being tumor-minded, I am one of the persons who has talked loudest and longest on that subject. It is the tumor that we are treating, not the skin, and it is most important that all of us shall realize that on all occasions. The reason we pay attention to the skin is that it is the door through which we send our radiation and we must know how wide we can open the door.

Some radiologists who are using higher voltages say that it isn't the skin reaction any more but that of the underlying tissues which is the limiting factor in dosage. In that case it will be necessary to find some way of studying these tissues.

For the present the skin is the thing which we can study by our method simply although laboriously. Investigation of other tissues, so far as I see, can be done only by careful clinical records and observations over long periods of time. No other biologic agent can be used, no other animal even can give us data which we may consider applicable to the human body.

roentgens, they are something like a hundred times as many ion pairs per cubic centimeter in the patient

But more than that, we know they are not roentgens from a practical standpoint because, depending upon whether we use an instrument of one manufacture or another, we sometimes measure 130 and we sometimes measure 160

We now see for the first time a possibility of counting, of having Dr Taylor count, the number of ion pairs produced in a cubic centimeter of our patient's skin. Then we will have the kind of an absolute measure which we can be confident of all the time for the future, in other words, we have before us a possibility of standardizing tissue dose in a unit which will not change

LAURISTON S TAYLOR, Ph D (Washington, D C) I would make only one remark concerning Dr Newell's discussion

It should not be inferred that, even if this type of ionization measurement is good for something, it will supplant at any time, the air ionization measurements which we are now accustomed to making. The likelihood of that is about zero

The value which I think Dr Newell had in mind was its putting us in a position possibly to establish a relationship between the number of ions produced in a liquid and the measurements which we ordinarily carry out with an air ionization chamber

The sole value in the work, as I see it, is that it will permit us to put perhaps a little bit closer interpretation on the measurements which we are now making routinely on patients or on experimental material

JAMES L WEATHERWAX, M A (Philadelphia) I want to thank Mrs Qumby and Dr MacComb [page 305] for the paper they have given. I know they must have put in a great deal of time in carrying on their experiments and I know the high quality of work that has been done

I wish to speak on the discussion pertaining to the saturation technic. This

is the only part of the paper that I will consider since I have done no experimental work in giving radiation fractionated as described

In 1925-1926, Dr Pfahler published a paper on the saturation technic based upon some work that had been done by Dr Kingery in 1921 with superficial radiation. At that time there was no organized method of giving radiation. Most radiation was given in a more or less hit-or-miss fashion. The saturation technic appealed to us because it was a technic that could be passed on to other radiologists

At that time, we chose 800 roentgens (in air) as a saturation dose with a loss factor of 5 per cent per day. We gave a total of about 1,600 roentgens (in air) to each field, treating multiple fields at the same sitting

Yesterday you heard Dr Ernst talking about being tumor-minded. We were at that time trying to treat the tumor rather than to treat the skin, so never gave a large initial dose to any one skin area, but instead, distributed the total radiation given a patient over all areas at the same sitting. Therefore, our method of applying the saturation technic was a fractionated technic somewhat comparable to our present-day fractionated technics, except that the total number of roentgens given any one skin area was less than is given to-day

Unfortunately, Dr Pfahler's first paper stressed a rather large initial dose of radiation to any one skin area. We never applied the saturation technic in this manner and doubt very much whether Dr Pfahler used a high initial dose. Other radiologists using the saturation technic gave small fractionated doses of radiation to multiple fields. Doses of 150 to 200 r (in air) were given every other day to multiple fields. In treatment of pelvic lesions, a patient would receive from 600 to 800 r (in air) distributed over multiple fields

We found as we went along with the saturation technic, that we were not giving the quantity of radiation at the rate we'd

than by means of this thimble ionization chamber

These studies that have been carried out have, fortunately or unfortunately as you may look at it, shown up some errors in our ways of thinking about these chambers. It is certainly to be hoped that, if we finally do adopt a thimble ionization chamber for a primary standard for gamma rays, the result of this work will have a direct and immediate bearing so that we will not have at any time in the near future to change our standards.

There is nothing more disconcerting to the radiologist than having to change standards every so often.

The thing of particular interest to me was the curves which the speakers showed in which the effect of the wall thickness on the ionization current was indicated. Several authors have decided as a result of their work that there is a definite saturation thickness for ionization chambers which must be used for all voltages in excess of 200 kilovolts.

I might remark that as long as there is such an arbitrary sort of a thickness necessary, it makes difficult the adoption of a single universal standard type of thimble ionization chamber.

It seems quite apparent in this work that these measurements, while they may apply to gamma rays, will probably not be necessary for the lower voltage x-rays

up to, say, five or six hundred kilovolts. That is a bit speculative but the evidence indicates that. If we can get away from that important arbitrary factor, it should be a great step in advance in using the thimble ionization chamber for measuring the supervoltage radiations.

The other point which I might mention is the use of Eve's number for proving the efficacy of a thimble ionization chamber for radiation measurements. It seems to me that too much weight has been attached to Eve's number in this connection, and Mr. Victoreen's work has indicated that the experimental determination of Eve's number depends to a large measure upon the particular configuration of the ionization chamber.

As long as it does that, there is something wrong with the measurements, and either we have to revise our thinking as to what Eve's number means or we must discard the entire theory as a criterion for the correct performance of one of these thimble chambers.

I did not mean by inference or direct statement to say that the thimble chamber was in the least discredited by these measurements. I feel very strongly quite the contrary, that the better we understand the process underlying the thimble chamber measurements, the more important the thimble chamber becomes.

Therefore, we are presenting this study, as I said in the beginning, as something which may be a contributing factor in helping us with our dosage technic

OTTO GLASSER, Ph D (Cleveland, Ohio)
Dr Stone and Dr Aebersold [page 296] should be congratulated on their splendid co-operation on a most important problem

I have emphasized several times in the past the fact that when we went from 200 kilovolts to higher voltages in radiation therapy, we changed practically all treatment factors—increased focal distance, increased filtration, increased voltage, and in addition, the introduction of the Coutard technic at about the same time

In most papers which have appeared on supervoltage therapy, the relative differences between the old and new treatment technic have not been presented in such a logical and clear-cut manner as is the case in this discussion by Dr Stone and Dr Aebersold. The paper fills a definite need because it states logically the difference in the physical factors between the two treatment technics and it states them authoritatively

I am quite sure that when comprehensive clinical results are published from Dr Stone's clinic, we can rely upon them to a greater extent than upon data which appear from supervoltage laboratories where no such careful comparison between the old and new technics under identical or similar conditions was carried out

JOHN VICTOREEN (closing) In general, anything which may have been said regarding the complex behavior of the thimble chambers says nothing against its practicability, since, normally, a thimble chamber is calibrated to agree with a standard air chamber, and that calibration provides protection against possible unknown variables

For instance, even though it can be shown that the ionization produced does not vary directly with the enclosed volume, this would be of no concern to the user, as it

would automatically be included in the original calibration

LAURISTON S TAYLOR, Ph D (Washington, D C) I am not at all sure that this Society and radiologists in general fully realize how much they owe to the efforts of Mr Victoreen [page 341], in particular, for the very satisfactory state of dosage measurements in this country

As you all know, we have throughout the country a great many of these dosage measuring instruments and it should be a source of great satisfaction to have seen the photograph which he showed of their standardization plant

It is particularly important for a manufacturer of any device to carry on research. It is very uncommon, I might add, for most manufacturers of instruments of this sort to carry on the type of research that has been reported this afternoon, and I think that we should congratulate Mr Victoreen for the thoroughness with which he has gone about this task

We have discussed the matter at some length before this actual presentation and I might remark that he has many data which have not been presented but which represent tens of thousands of measurements over the past few months, and which undoubtedly will have a direct bearing on the future of ionization chambers

This work has been particularly timely. At the last International Congress we were very nearly compelled to accept as an international standard a thimble ionization chamber for all voltages in excess of 200 kilovolts. We felt at the time, that while the work seemed to be in a fairly satisfactory state, there might be a little uncertainty and in that feeling we met a great deal of opposition

There is no question but that for the time being, at least, we shall have recourse only to the thimble ionization chamber for measuring gamma rays. We cannot see at the present moment any other type of chamber—at least with clinical measurements—whereby it will be possible to measure gamma rays in roentgens other

TABLE I—RESULTS OF TRANSPLANTING MOUSE SARCOMA 180 AFTER EXPOSURE TO FILTERED ROENTGEN RAYS (200 KV, 30 MA, 0.5 MM CU + 1.6 MM AL FILTER) *in vivo*

No of Animals	Dimension of Tumor (mm)	Dose in Roentgens	Interval between Irradiation and Implantation	No of Tumor Transplants Used	Growth of Transplants (percentage)
1	7.5 × 6.1 × 4	2,830	0 25 hrs	10	0
2	6.8 × 6.5 × 4	2,830	2 hrs	10	0
3	6.2 × 4.5 × 3	2,830	2 hrs	10	0
4	7.5 × 6.0 × 3	2,830	1 day	12	17
5	5.5 × 4.5 × 3	2,830	1 day	10	0
6	6.0 × 6.2 × 3	2,830	1 day	10	0
7	6.2 × 6.2 × 4	2,830	3 days	10	0
8	10.5 × 8 × 6	2,830	5 days	16	0
9	7.1 × 6.8 × 5	2,830	7 days	10	0
10	6.5 × 5.0 × 3	1,500	0 25 hrs	10	90
11	11.5 × 7.5 × 5	1,500	0 5 hrs	10	90
12	8.0 × 6.3 × 4	1,500	1 hr	10	80
13	9.0 × 7.6 × 5	1,500	2 hrs	10	60
14	10.0 × 8 × 5	1,500	2 hrs	10	90
15	6 × 6 × 4	1,500	2 hrs	10	70
16	9.5 × 6.5 × 5	1,500	2 hrs	10	60
17	5.5 × 4.5 × 2	1,500	1 day	10	20
18	8.9 × 6.8 × 4	1,500	1 day	10	40
19	7.9 × 6.8 × 4	1,500	1 day	10	60
20	9.2 × 7.6 × 5	1,500	1 day	10	80
21	7.6 × 6.6 × 4	1,500	1 day	10	20
22	7.5 × 7.2 × 4	1,500	1 day	14	86
23	7.0 × 6.8 × 4	1,500	2 days	10	80
24	8.5 × 7.3 × 4	1,500	2 days	10	40
25	5.8 × 4.5 × 3	1,500	3 days	10	40
26	9.2 × 6.5 × 5	1,500	3 days	10	60
27	10.8 × 8.2 × 5	1,500	4 days	10	50
28	7.0 × 6.2 × 4	1,500	4 days	10	20
29	7.5 × 5.5 × 3	1,500	5 days	10	10
30	5.1 × 4.5 × 3	1,500	5 days	10	20
31	9.5 × 7.8 × 5	1,500	5 days	10	30
32	10.5 × 8.2 × 6	1,500	6 days	10	0
33	9.2 × 7.8 × 6	1,500	6 days	10	0
34	8.0 × 7.5 × 4	1,500	7 days	10	0
35	8.2 × 7.5 × 5	1,500	7 days	10	40
36	6.2 × 5.5 × 4	1,500	7 days	10	0
37	5.8 × 5 × 3	1,500	7 days	12	0
38	9.8 × 7 × 5	1,500	8 days	10	70
39	9.7 × 7 × 5	1,500	8 days	10	0
40	7.8 × 6.8 × 4	1,500	10 days	10	60
41	7.2 × 6.0 × 4	1,500	10 days	10	0
42	6.7 × 6.3 × 4	1,500	10 days	10	0
43	6.3 × 5 × 3	1,500	10 days	10	0
44	8 × 7 × 5	1,500	14 days	10	0
45	7.5 × 6 × 3	1,500	14 days	10	0
46	7.8 × 7.5 × 4	500	1 hr	14	100
47	7.5 × 6.8 × 4	500	2 hrs	10	100
48	6.5 × 6 × 3	500	1 day	10	100
49	8 × 6.5 × 5	500	3 days	10	100
50	9.2 × 8.5 × 6	500	7 days	10	100
51	5.2 × 4.8 × 3	500	14 days	15	100

are less apt to grow than when they are irradiated and transplanted immediately. He attributes this difference to the effect of radiation on the blood supply. Kawakami (10) reported that if Kato rabbit sarcomas are irradiated with x-rays (3 to 20 SED) while in the hosts, and immediately extirpated and implanted in other non-irradiated rabbits, they will grow progressively. But, if they are allowed to remain in the

original hosts for 17 hours after irradiation with a dose as small as 5 SED, many of them fail to grow. He believes that the difference is due to the disturbance of the irradiated connective tissues. As these observations have some bearing on the therapeutic uses of x-rays and radium, more experiments on much the same lines have been carried out.

When tumor grafts (Mouse Sarcoma

STUDIES ON RADIOSENSITIVITY OF MOUSE SARCOMA 180 IRRADIATED *IN VIVO* AND *IN VITRO*

By KANEMATSU SUGIURA, D M Sc, New York City

From the Huntington Fund for Cancer Research, Memorial Hospital

EXPERIMENTAL studies of Murphy, Maisin, and Sturm (1), Russ and Scott (2, 3) and Mottram (4) have clearly demonstrated that the lethal dose of roentgen rays or gamma rays from radium for tumors growing *in animals* is much smaller than the dose required to kill the same tumors *in vitro*. The results are confirmed and extended by our recent studies (5, 6, 7)

Figure 1 shows the survival curves of Mouse Sarcoma 180 exposed *in vivo*¹ and *in vitro*² to 200 kv roentgen rays, filtered

the dose of filtered roentgen rays necessary to kill all the fragments of tumor is between 2,800 and 3,000 roentgens (measured in air). When tumor implants growing in animals are treated with similar radiation, the dose necessary to cause complete regression is about 1,800 roentgens. The nature of this reaction is complex, and little light has been thrown on its mechanism in the last ten years (8)

The present study was undertaken to gain further information regarding the mechanism of the radiosensitivity of tumors

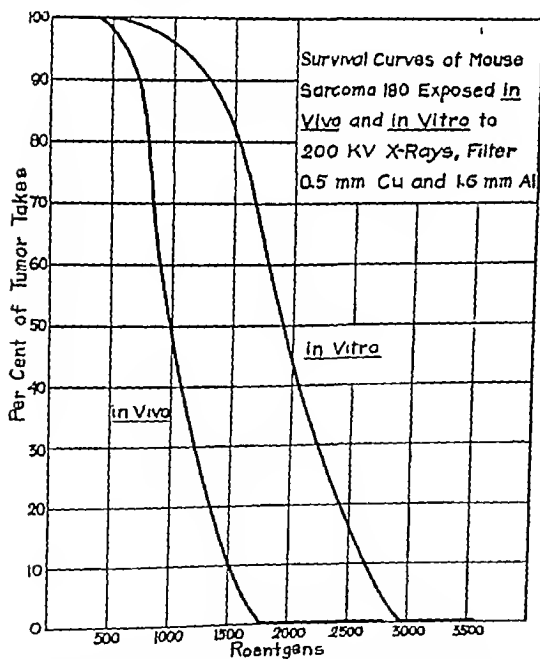


Fig 1 Survival curves of Mouse Sarcoma 180 exposed *in vivo* and *in vitro* to 200 kv roentgen rays filter 0.5 mm Cu and 1.6 mm Al

with 0.5 mm Cu and 1.6 mm Al, at a distance of 50 cm. It shows that when Mouse Sarcoma 180 is irradiated *in vitro*

¹ This group involved 156 irradiated tumors

² This study consisted of 21 groups of experiments involving a total of 910 irradiated tumor implants

IRRADIATION OF TUMORS *IN VIVO*

In a previous study (7) we found that when tumors, 0.3 to 1.5 cm in diameter, were irradiated *in vivo* through a hole in a lead shield slightly larger than the cross-section of the tumor, no tumor regressed with a dose of less than 500 r, and very few with less than 750 r. With a dose of 1,000 r, about 50 per cent of cases showed regressions. With a dose of 1,500 r, about 85 per cent of cases showed complete regression, but with a dose greater than 2,000 r, tumor regression occurred in 100 per cent of cases. These successfully treated tumors disappeared completely in about 24 days. However, we do not know the length of time which elapses from the first disturbance until the tumor cell dies. There are, however, a limited number of reports upon the latent effect of radiation *in vivo*. Thus Mottram (9) irradiated tumors (Mouse Sarcoma 180) in mice with 20 mg of radium element for 20 minutes. After varying lengths of time the tumors were removed and fragments were implanted into normal animals. The results showed that if tumors are left for four or five days in the animal after irradiation, and then removed and transplanted into other animals, they

(Fig 2-C) At this point the cellular swelling is greatest (Fig 3) The volume of these swollen cells is approximately twelve times that of the normal tumor cells⁴ The cytoplasm appears granular,

of polymorphonuclear leukocytes and lymphocytes The major part of each section taken from irradiated tumors remaining seven days in the hosts is composed of degenerating tumor cells in which the

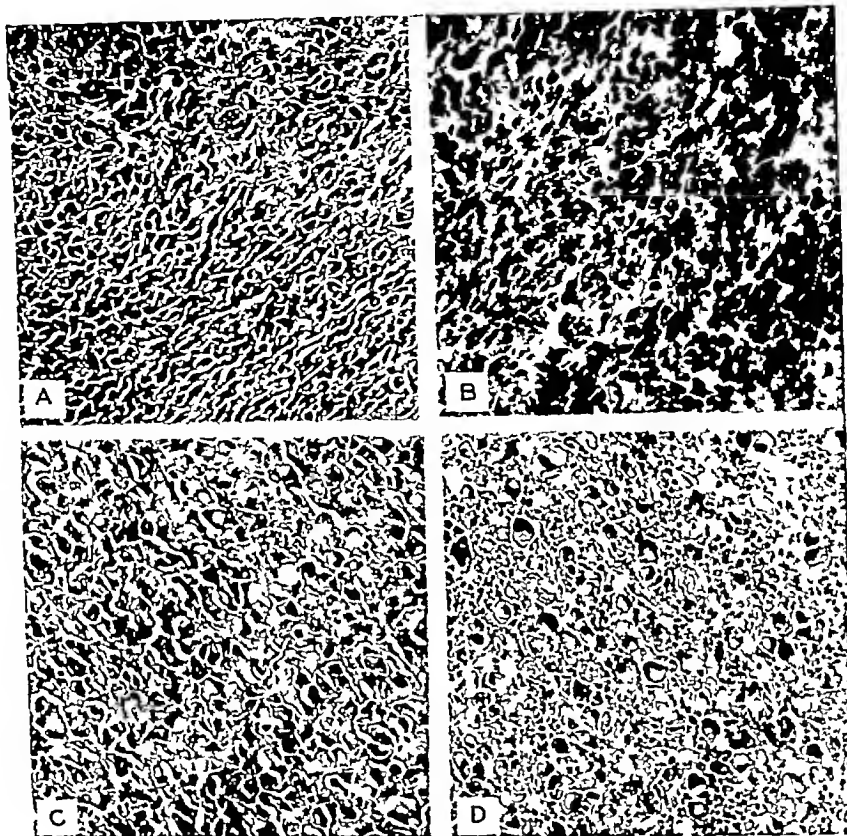


Fig 2 Showing changes in histologic appearance in irradiated tumors Photomicrographs of sectioned material were made at the same magnification 180 times A is untreated Mouse Sarcoma 180 B C and D are Mouse Sarcoma 180 irradiated *in vivo* with a dose of 1 500 r and allowed to remain one three or seven days in the host respectively

and some areas are finely vacuolated At the periphery, many active tumor cells and mitotic figures are seen Polymorphonuclear leukocytes and lymphocytes are present in much greater number than in non-irradiated tissues Tumors remaining five days in the original irradiated animals show marked radiation changes, with swelling of tumor cells, decrease in the number of mitotic figures, and infiltration

⁴ The relative volume of irradiated and non irradiated tumor cells was computed by actual measurements of photomicrographs of sectioned material made at the same magnification (300 times)

nuclei are absent or pycnotic There is marked lymphocytic and polymorphonuclear infiltration No viable tumor cells can be seen in the sections (Fig 2-D)

TUMOR INOCULATION IN X-RAYED AREAS

The foregoing results show that the surrounding normal tissues and the host as a whole must play an important part in the tumor reaction to radiation

Next we determined the rate of recovery of normal tissues after irradiation, *i e*, recuperation of tissues from the damage

180) had grown for about seven days in animals, they were irradiated with a dose of 2,830 r, 1,500 r, or 500 r in the same manner as that previously described.³ The radiation was supplied by a standard water-cooled Coolidge roentgen tube under the following conditions: 200 kv, 30 ma, 0.5 mm Cu + 1.6 mm Al filter, 50 cm target-skin distance, and intensity of 59 r/min. At the end of definite intervals of time the irradiated tumors were removed from the animals and tumor fragments were inoculated into normal animals in the usual way. At the same time pieces of treated tumor tissues were fixed in formalin for histologic examination.

The results obtained from transplanting tumors irradiated *in vivo* are presented in Table I. In the second column of the table the sizes of the tumors at the time of irradiation are denoted by the measurements of length, width, and thickness. The time elapsing between the irradiation of tumors and the removal of the tumors from the hosts for re-implantation is expressed in hours or days in the fourth column. Each set of experiments included as a control the inoculation of animals of about the same age with untreated tumor tissue. This control group of 20 sets involved 352 tumor implants. Eighteen of them gave 100 per cent tumor takes and the remaining two sets gave 95 and 90 per cent takes, respectively. These results however, are omitted in Table I. The data are arranged according to the increasing length of time between irradiation and the removal of the tumor from the original host with implantation into new animals.

As may be seen from the data in Table I the results are not clear-cut. Natural resistance in the individual animals may well have some influence upon the radiosensitivity of the tumor. However, certain observations may be made. If tumors are irradiated *in vivo* with a dose of 2,830 r and then removed and transplanted into other animals, they fail to grow whether the tumors are left in the original hosts for one

hour or several days before re-implantation.

If tumor implants, grown for about seven days in animals, are treated with 1,500 r while in the host, and immediately removed and implanted in other non-irradiated mice, about 80 per cent will grow progressively as is the case of tumor fragments irradiated *in vitro* with the same dose of roentgen rays. If they are allowed to remain in the original hosts for 24 hours before re-implantation, only 50 per cent takes will result, while complete inhibition of growth generally will occur in those left in the original animals six days or longer (11 out of 14 experiments).

If tumors are irradiated with a dose of 500 r and left several days in the animal and then transplanted, they grow as well as when they are irradiated and immediately removed and transplanted.

The irradiated tumors actually increased in size during the first week after irradiation. The enlargement of the tumor tissue may have been due merely to edema rather than actual cell proliferation. The swelling of tumors following irradiation has been abundantly described (Ewing, 8; Lacasagne and Monod, 11; Mottram, 12; Stewart, 13, and others).

Histologic examinations of a number of the irradiated tumor tissues show that the variation in the viability of tumor fragments at different intervals after irradiation (with a dose of 1,500 r) can be correlated with changes in their histologic appearance. The general structure of the non-irradiated tissue shows a very cellular, small spindle and polyhedral cell sarcoma, degenerated and necrotic in some areas (Fig 2-A). In some sections, leukocytes are seen at the periphery. The sections of irradiated tissues taken within two hours after irradiation show no definite changes, the tumor cells appearing to be viable. The sections taken 24 hours after irradiation reveal numerous swollen tumor cells and intercellular edema (Fig 2-B). Tumors remaining three days in the hosts show markedly swollen tumor cells covering almost the entire area of the section.

³ The area irradiated is about 2.9 sq cm.

TABLE II—RESULTS OF TRANSPLANTING MOUSE SARCOMA 180 INTO PREVIOUSLY IRRADIATED AREAS ON THE ANIMAL

Exp No	Number of Animals Used	Dose in Roentgens	Interval between Irradiation and Implantation	Percentage of Tumor Takes	Remarks
1	24	Controls	0	100	Rapid growth
	12	500	2 hrs	100	Rapid growth
	12	500	7 days	100	Rapid growth
2	30	Controls	0	100	Three tumors grew slowly, others grew rapidly
	10	500	2 hrs	100	Two tumors grew slowly, others grew rapidly
	10	500	3 days	100	Rapid growth
	10	500	8 days	100	Two tumors grew slowly, others grew rapidly
	10	500	14 days	100	Rapid growth
3	20	Controls	0	100	Rapid growth
	10	1 500	2 hrs	0	No growth
	10	1 500	8 days	100	Two tumors grew slowly, others grew rapidly
	10	1 500	8 days	100	Rapid growth
4	15	Controls	0	100	One tumor did not grow two grew slowly
	3	1 500	2 hrs	86	One tumor did not grow, one grew slowly, one grew rapidly
	3	1,500	1 day	86	Rapid growth
5	3	1 500	3 days	100	Rapid growth
	10	Controls	0	100	Two tumors did not grow, others grew slowly
	5	1 500	2 hrs	60	All grew very slowly
6	5	1,500	4 days	100	Three tumors grew slowly, others grew rapidly
	20	Controls	0	100	Four tumors did not grow, four grew slowly, two grew rapidly
	10	1,500	2 hrs	60	Four tumors grew slowly, others grew rapidly
7	10	1,500	4 days	100	Rapid growth
	30	Controls	0	100	Six tumors did not grow, others grew slowly
	10	1,500	2 hrs	40	Four tumors did not grow, others grew slowly
8	10	1,500	1 day	60	Four tumors grew slowly, others grew rapidly
	10	1,500	7 days	100	Two tumors grew slowly, others grew rapidly
	5	Controls	0	100	Three tumors did not grow, others grew slowly
9	5	1 500	2 hrs	40	Rapid growth
	15	Controls	7 days	100	Rapid growth
	5	1 500	0	100	Two tumors did not grow, two grew slowly one grew rapidly
10	5	1 500	1 day	60	Rapid growth
	10	Controls	22 days	100	Rapid growth
	5	1 500	0	100	Two tumors did not grow, others grew slowly
11	5	1 500	2 days	60	One tumor did not grow, others grew slowly
	15	Controls	7 days	80	Rapid growth
	5	1 500	0	100	Rapid growth
12	5	1 500	6 days	100	Rapid growth
	10	Controls	15 days	100	Rapid growth
	5	1 500	0	100	Rapid growth
13	5	1 500	7 days	100	Rapid growth
	5	1 500	15 days	100	Rapid growth
	20	Controls	0	95	One tumor did not grow, three grew slowly others grew rapidly
14	3	2 830	0	0	No growth
	3	2 830	2 hrs	0	One tumor did not grow, one grew slowly, one grew rapidly
	3	2 830	1 day	66	One tumor did not grow one grew slowly others grew rapidly
	4	2 830	4 days	75	Rapid growth
15	10	Controls	0	100	Rapid growth
	6	2 830	2 hrs	100	All grew slowly
	6	2 830	7 days	100	Three tumors grew slowly, others grew rapidly
15	10	Controls	0	100	Rapid growth
	6	2 830	0	100	One tumor did not grow, four grew slowly one grew rapidly
	6	2 830	2 hrs	83	One tumor did not grow, three grew slowly two grew rapidly
15	6	2 830	14 days	83	One tumor did not grow, three grew slowly two grew rapidly

caused by radiation as shown by their susceptibility to tumor transplants

Small areas of the skin on the lateral thoracic region of healthy young adult mice were shaved. The mice were fastened

dose of 500 r grew equally as well as fragments inoculated in the non-irradiated controls, whether tumor implantation was done immediately or several days after irradiation. This is in accord with the

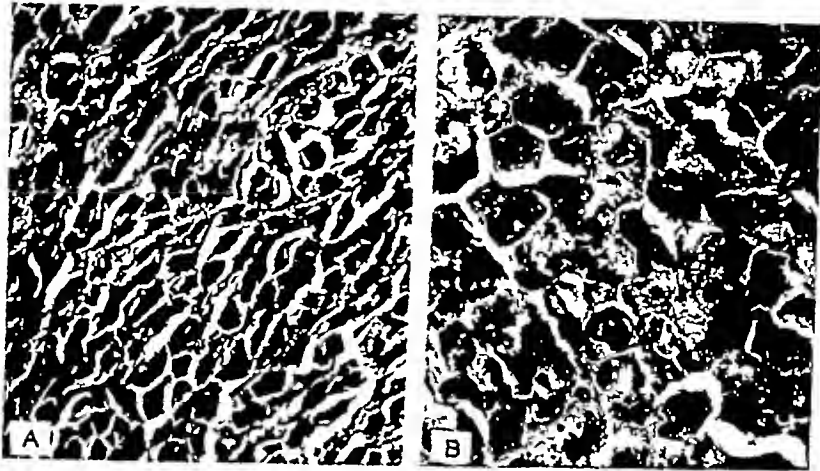


Fig 3 Showing the relative sizes of non irradiated and irradiated tumor cells. Photomicrographs of sectioned material were made at the same magnification, 300 times. A is untreated Mouse Sarcoma 180, B is Mouse Sarcoma 180 irradiated *in vivo* with a dose of 1500 r and allowed to remain three days in the host.

side by side, two at a time, on a stiff pasteboard. A lead-celluloid shield, having a hole 2×2.9 cm in the center, was then placed over these animals with their ventral skin touching the celluloid. In this way all parts of the animal except a small area were protected from radiation. Then the pasteboard holding the animals was placed directly under the roentgen tube with a target-skin distance of 50 cm, and subjected to radiation under the conditions previously described, intensity being 59 r per minute. Exposures were 8.5, 25.4, and 48 minutes.

Some animals were inoculated in the center of the irradiated area with a fresh tumor fragment (Mouse Sarcoma 180) immediately after irradiation. Others were similarly treated from one to 22 days after irradiation. As a control, another series of animals was treated in the same manner except that no x-rays were given. The results of the individual experiments are shown in Table II.

From the data in Table II, it will be seen that the tumor fragments inoculated in the areas irradiated previously with a

findings of Murphy, Hussey, Nakahara, and Sturm (14, 15) who, working with Bashford Mouse Carcinoma 63, found that subcutaneous inoculations of the grafts in the x-rayed areas (one erythema dose) resulted in the same number of growths as in the normal areas. However, if the inoculations were done intracutaneously, the grafts in the x-rayed areas showed a low percentage of takes.

The use of different transplantable tumors combined with various qualities of radiation, intensity of radiation and the size of irradiated area has led to varying results and, therefore, much controversy. On implantation of tumor fragments (Ehrlich mouse carcinoma) into an irradiated area Kok and Vorlaender (16), and Kok (17) obtained best retrogressive changes with a dose of about 1.5 SED. Large doses (2.9 SED) gave poorer results. They also found that irradiation of a large field around the tumor gave fewer takes than did irradiation of a small area. They interpret the resorption of the tumor tissue to the action of the histiocytes. On the other hand, Juul (18) obtained most re-

isotonic, hypotonic, and hypertonic Locke-Ringer solutions⁶ These media had been buffered to pH 7.4 by adding 0.08 c.c. of 0.2 M KH_2PO_4 and 0.05 c.c. of 0.2 M KOH (21) The weighing bottles containing the tumor fragments were kept in a refrigerator at 4–5° C for 24 hours, and then the fragments were inoculated into normal mice Our observations are recorded in Table III In this table are also included results obtained from inoculation of irradiated tumor tissues without immersion in a Locke-Ringer solution, and from inoculation of non-irradiated tumor tissues after immersion in isotonic, hypotonic, and hypertonic Locke-Ringer solutions These will serve as controls

The results show that the growth capacity of irradiated tumor fragments is reduced from 82 to 64 or 75 per cent takes when subjected to an isotonic or hypotonic medium for 24 hours, respectively However, the tumor fragments which have been irradiated and then immersed in hypertonic Locke-Ringer solution for 24 hours give 100 per cent takes when transplanted into normal animals

Parallel experiments were run with non-irradiated tumor fragments The results showed that immersion of tumor fragments in isotonic, hypotonic, or hypertonic Locke-Ringer solution for 24 hours was without effect the tumors grew rapidly

Gross and histologic examination of a number of tumor tissues after immersion in isotonic, hypotonic, and hypertonic Locke-Ringer solutions for 24 hours at 4–5° C following irradiation showed no essential difference

In a separate experiment, it was found that 15 pieces of irradiated tumor tissue (1,500 r) before immersion in isotonic, hypotonic, or hypertonic Locke-Ringer solution (pH 7.4) weighed 0.1660 gm, 0.1697 gm, and 0.1482 gm, respectively, and after immersion for 24 hours at 4–5° C they

weighed 0.1808 gm (109 per cent), 0.1873 gm (110 per cent), and 0.1596 gm (108 per cent), respectively In a simultaneous experiment, 15 non-irradiated tumor fragments before immersion in isotonic, hypotonic, or hypertonic Locke-Ringer solution weighed 0.1464 gm, 0.1712 gm, and 0.1635 gm, respectively, and after immersion they weighed 0.1505 gm (103 per cent), 0.1815 gm (106 per cent), and 0.1625 gm (99 per cent), respectively The swelling was greater in irradiated tissue than in non-irradiated tissue

This work is being continued and extended to include a study of the effects of different intensities of radiation upon the swelling of tumor tissues

SUMMARY

1 The effect of 200 kv roentgen rays on Mouse Sarcoma 180 in animals has been studied Tumors, 0.5 to 1.2 cm in diameter, were irradiated *in vivo* through a hole in a lead shield slightly larger than the cross-section of the tumor

2 It requires about 60 per cent more roentgen irradiation to kill Mouse Sarcoma 180 *in vitro* than *in vivo*

3 If this tumor is irradiated *in vivo* with a dose of 1,500 roentgens (measured in air), and subsequently removed and fragments implanted into non-irradiated mice, the percentage of takes decreases with the time the tumor remains in the original host after exposure

4 Variations in the viability of tumor fragments at different intervals after irradiation can be correlated with changes in their histologic appearance

5 If small portions of the bodies of mice are irradiated with a dose of 1,500 r and at the end of definite intervals of time untreated tumor fragments are inoculated into the irradiated areas, a high percentage of tumor transplants will fail to grow if the implantation is done within two hours after irradiation If untreated tumor fragments are implanted in the irradiated areas seven days after irradiation, the number of tumor takes and the rate of tumor growth is almost normal

⁶ An isotonic solution contained 0.15 moles NaCl 0.003 moles KCl and 0.003 moles CaCl_2 per liter A hypotonic solution contained 0.12 moles NaCl 0.003 moles KCl and 0.003 moles CaCl_2 per liter A hypertonic solution contained 0.18 moles NaCl 0.003 moles KCl and 0.003 moles CaCl_2 per liter

gressions from doses close to twice the epilation dose, which caused serious injury to normal tissues surrounding the tumor. He worked with Krebs' mouse adenocarcinoma and mouse sarcoma. Russ and Scott (19) found that the transplants (Jensen rat sarcoma and hemorrhagic carcinoma R 9) grew more slowly in an area which had been previously irradiated with x-rays or radium than in a non-irradiated area. Their roentgen-ray exposures were from 20 to 45 minutes. It took 20 minutes to produce epilation, and 45 minutes to start vesication. In these experiments rats were completely screened with lead except for two apertures cut in the lead, through which the x-rays could reach the skin of the animals. Krebs (20) carried out experiments similar to that of Murphy and his co-workers (14), but using somewhat stronger doses (5 to 6 S N). He found that roentgen irradiation of the skin has demonstrable inhibitory effect on the growth of a mouse carcinoma subsequently implanted in the irradiated intracutaneous or subcutaneous tissues, though the effect was always pronounced in the cutis. In the case of implantation of a mouse sarcoma in the irradiated area (subcutaneous tissue), there was a distinct retardation in tumor growth, but no reduction in percentage of tumor takes.

In our experiments using 1,500 r, there is a decided difference in the number of growths from tumor fragments inoculated subcutaneously in the areas irradiated, between those inoculated immediately and those inoculated several days after irradiation. About 50 per cent of tumor implants will fail to grow if the implantation is done within two hours after irradiation, and those which do not disappear in the irradiated area will grow at a much slower rate than the controls. If untreated tumor fragments are implanted in the irradiated areas seven days after irradiation, the number of tumor takes and the rate of tumor growth is almost normal. Evidently some changes which oppose tumor growth take place in normal tissues irradiated with this dose. Whatever these changes are,

they gradually tend to disappear and are practically gone in seven days.

Experiments duplicating those with a dose of 1,500 r were made with a dose of 2,830 r. The results of the experiments showed that the tumor growth was less marked in the irradiated than in non-irradiated areas, but this dose induced injury to the general health of the hosts, which made the process of tissue repair more complex.

EFFECT OF ISOTONIC, HYPOTONIC, AND HYPERTONIC LOCKE-RINGER SOLUTIONS ON VIABILITY OF MOUSE SARCOMA 180 FOLLOWING EXPOSURE TO X-RAYS

The results of the foregoing experiments show that the marked decrease in the transplantability of tumors upon remaining in the original irradiated animals parallels closely the increase in the swelling of tumor cells. The death of tumor cells may be due to this swelling. In the present study experimental evidence has indicated that the swelling of tumor cells is not a postmortem change.

In a recent meeting of the American Association for the Advancement of Science,⁵ Failla outlined a new theory regarding the biologic effect of radiation. He suggested that upon bombardment of tumor cells by x-rays the cytoplasm may be affected in such a way as to cause an increase in the number of electrolytic ions in the cells. Such a change would disturb the osmotic equilibrium of the cells and result in swelling. He suggested that the lethal effect of the rays was possibly due to an initial swelling and consequent dilation of the cytoplasm which interferes with the normal physiologic processes.

In order to secure further information concerning the swelling and killing of tumor cells, we made the following experiments.

Fragments of fresh Mouse Sarcoma 180 in a cellophane moist chamber were irradiated with a dose of 1,500 r. Immediately afterward equal numbers of tumor fragments were placed in 20 c c portions of

⁵ Atlantic City N. J. Dec. 29 1936-Jan. 1, 1937

of the work, and to Dr F W Stewart for histologic examination of sections of irradiated and non-irradiated tumors

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TABLE III —RESULTS OF TRANSPLANTING MOUSE SARCOMA 180 AFTER IMMERSION IN LOCKE-RINGER SOLUTION AT 4-5° C FOLLOWING EXPOSURE TO FILTERED ROENTGEN RAYS

Exp No	Number of Tumor Transplants Used	Dose in Roentgens	Nature of Locke Ringer Solution	Duration of Exposure (hours)	Growth of Transplants (percentage)	Remarks
1	10	0	Isotonic	24	100	Rapid growth
	10	0	Isotonic	48	100	Rapid growth
	10	0	Hypotonic	24	100	Rapid growth
	10	0	Hypotonic	48	100	Rapid growth
	10	0	Hypertonic	24	100	Rapid growth
	10	0	Hypertonic	48	100	Rapid growth
2	10	1 500	0	0	80	Two tumors did not grow, four grew slowly others grew rapidly
3	10	1,500	0	0	80	Two tumors did not grow two grew slowly others grew rapidly
4	10	1,500	0	0	80	Two tumors did not grow six grew slowly, others grew rapidly
	10	1 500	Isotonic	24	60	Four tumors did not grow four grew slowly, others grew rapidly
	10	1 500	Isotonic	48	60	Four tumors did not grow four grew slowly others grew rapidly
	10	1 500	Isotonic	72	50	Five tumors did not grow three grew slowly, others grew rapidly
	10	1 500	Isotonic	90	50	Five tumors did not grow, two grew slowly others grew rapidly
	10	1,500	0	0	83	Three tumors did not grow eight grew slowly others grew rapidly
5	10	1,500	Isotonic	24	50	Five tumors did not grow, two grew slowly others grew rapidly
	10	1,500	Hypotonic	24	80	Two tumors did not grow five grew slowly others grew rapidly
	10	1,500	Hypertonic	24	100	Seven tumors grew slowly, others grew rapidly
	10	1,500	0	0	83	Two tumors did not grow three grew slowly, others grew rapidly
6	10	1,500	Isotonic	24	80	Two tumors did not grow, four grew slowly, others grew rapidly
	10	1 500	Hypotonic	24	80	Two tumors did not grow five grew slowly others grew rapidly
	10	1,500	Hypertonic	24	100	Five tumors grew slowly, others grew rapidly
	10	1 500	0	0	80	Two tumors did not grow one grew slowly, others grew rapidly
7	10	1,500	Isotonic	24	70	Three tumors did not grow four grew slowly, others grew rapidly
	10	1 500	Hypotonic	24	80	Two tumors did not grow six grew slowly, others grew rapidly
	10	1 500	Hypertonic	24	100	Four tumors grew slowly, others grew rapidly
	10	1,500	0	0	90	One tumor did not grow, three grew slowly others grew rapidly
8	10	1,500	Isotonic	24	60	Four tumors did not grow, others grew slowly
	10	1 500	Hypotonic	24	60	Four tumors did not grow two grew slowly, others grew rapidly
	10	1,500	Hypertonic	24	100	Four tumors grew slowly, others grew rapidly
	10	1,500	Hypertonic	24	100	Four tumors grew slowly, others grew rapidly

6 The effect of immersion in isotonic, hypotonic, and hypertonic Locke-Ringer solutions on irradiated and non-irradiated tumor tissues has been investigated non-irradiated tumor tissue showed no effect from any of these solutions, while the growth capacity of irradiated tumor tissue

was reduced by immersion in isotonic and hypotonic solutions, but was increased by immersion in the hypertonic solution

Acknowledgment—I wish to express my thanks to Dr G Failla for his co-operation and valuable suggestions during the course

The same end-results may be obtained by the use of the x-rays as by radium, or by the two combined. In most instances we prefer to use the x-rays because for their use the patient does not require hospitalization and is not subjected to any surgical procedure. The total to be given can more conveniently be divided into several doses, allowing more time and a better chance to gain the confidence of the patient, which is a matter of great importance in the future management of the cases. There is no danger of latent infection in the pelvis flaring up when the x-rays are used, while with radium this sometimes proves serious. Often after the use of radium there is an irritating discharge which causes considerable discomfort for two or three months.

In cases in which we consider it necessary to check the bleeding quickly we use radium, also in cases on which we do diagnostic curettement because we suspect cancer of the fundus.

We find that in some cases in which x-rays are used it is best to supplement with radium, and *vice versa*.

We have started treatment to produce permanent menopause in the cases of 41 women who discontinued treatment after having from one to three irradiations. Some of these had good results for a time but they were not lasting. A few of these are now well, but we expect recurrence, so they will not be included in a report of results obtained.

We have attempted to produce cure by bringing about temporary menopause in 20 patients, six of whom have re-established normal menstrual function. Four of our patients have had children and one an abortion subsequent to this treatment.

Of the patients in whom we attempted to produce permanent menopause we have fully traced 327, who were treated until cured or until other treatment was recommended by us. From this number we report our results.

Total number traced 327

Cured 313 (95.7 per cent)

In eight of the 14 uncured cases there was contra-indication to treatment, which leaves 319 cases treated in which there were no contra-indications. Of these, 313 were cured while six did not get satisfactory results—98.1 per cent cured.

In 16 of these cases it was necessary to give a second series of treatment. In this number are included eight cases in which temporary menopause was not effective.

Of the eight who had contra-indications to treatment, five were incorrectly diagnosed—two had carcinoma of the fundus, one had had diagnostic curettement a month before coming to us for treatment and no cancer was found, the other did not show satisfactory response and the uterus was curetted and treated with radium. Both had hysterectomy and are living and well after eight and ten years, respectively. One had varicosities in the uterus and required hysterectomy. One had polyp, and one ovarian cyst, both requiring surgery. In both of these cases the menopause was permanent and probably should not have been produced. Three had, prior to treatment, subtotal hysterectomy, a part of the uterus being left. Two of these had hysterectomy completed, and the other should have had. We have treated five of these cases, two of which we have been unable to follow up. We believe that these cases should not have been treated by radiation, although all secured temporary relief. In the other six cases we were unable to determine the reason for failure.

We have had one patient on whom hysterectomy was done following the satisfactory production of the menopause, because of a remaining small fibroid.

The menopausal symptoms were mild in 67 per cent, of moderate degree in 30 per cent, while of severe degree in 3 per cent of the cases.

Of the patients, 74 per cent were married when treated or had been married, while 26 per cent were unmarried. Of the married, 77 per cent had borne from one to eighteen children each.

Fibroid tumor was found in 14 per

RADIATION THERAPY IN EXCESSIVE UTERINE BLEEDING FROM CAUSES OTHER THAN CANCER

REPORT ON 327 CASES

By ROBERT H LAFFERTY, M D , and C C PHILLIPS, M D , *Charlotte, N C*

FOR many years we have been studying and practising irradiation in the treatment and management of menorrhagia, and the study of the literature and our cases over a period of seventeen years has brought us to the conclusion that radiation is the method of choice in the treatment of these cases

To this method, as to all others, there are certain contra-indications, such as very large rapidly growing fibroids, those causing pressure symptoms demanding quick relief, pedunculated tumors, uterine polypi, tumors which can be removed leaving the uterus intact, tumors which have undergone cystic degeneration, ovarian cysts, extreme mental depression, and cases in which partial hysterectomy has been done and bleeding continues from residue of uterus. Also, we believe that no woman in the child-bearing period and having no tumor should be subjected to radiation until all other methods of treatment short of hysterectomy have failed to effect cure

The idea is rather prevalent in the medical profession, and it has permeated the laity to some extent, that radiation destroys the woman's sexual desire and enjoyment. As to this, we have interviewed and followed through the cases of 58 of the patients in this series. We find that in 40 of these there was no change in sex life, in nine, desire and capacity were reduced for a time, but normal sex power returned, in seven, two of whom were frigid before treatment, there was increase ranging from a moderate to a marked degree, one, aged 50 when treated has remained sexually insensitive for ten years, and one has remained much below normal in this sense for ten years, although she has sex powers to a limited extent. These findings convince us that, following radiation, there is more apt to be increase than decrease in

sexual desire and enjoyment. We are convinced also that any change in this respect is entirely psychic. We find that recovery from lowered or lost sexual appetite promptly follows positive assurance and conviction that recovery will occur.

The greatest care should be given to the selection of these cases, so that those having positive contra-indications may not be subjected to treatment.

We find that a very large percentage of these patients have been treated for a long time by various methods without satisfactory results, and on account of this they are very apprehensive and doubtful about any treatment curing them, consequently, it is of great importance that sufficient time and effort be taken to fully discuss with the patient all phases of the treatment and just what is to be expected from it. Our experience has taught us to expect one, and sometimes two, menstrual periods during the time which is required to establish permanent menopause and the flow is usually profuse at the first period. Some have radiation sickness, while almost all of them experience some discomfort from the usual menopausal symptoms. The patient should be told of all this and assured that none of the conditions is in any way serious. Since there is a small chance of temporary loss of sexual interests this should be discussed with the patient and she should be assured that in case this occurs it will be temporary only.

Those experiencing considerable annoyance from the menopausal symptoms we find can be relieved by the intramuscular use of estrogen. We generally give one cubic centimeter every other day for six doses. In a few cases this must be repeated every few months until the patient becomes stabilized.

SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM¹

(Second Series, Third Installment)

By I S TROSTLER, M D, F A C R, F A C P, Chicago

ABUSE OF WITNESSES DURING CROSS-EXAMINATION

RECENTLY, a colleague whom I have known for about thirty years, wrote me as follows "I have just passed through a most harrowing and tormenting experience and turn to you for advice and solace

"I was called into court this morning to testify as an expert witness by the attorney for a man whom I had attended in consultation with his attending physician, following an automobile accident. Our patient was suing for damages resulting from the accident in which he was injured

"After answering the questions put to me by the patient's attorney, I was cross-examined by the bull dog who represents the insurance company, the defendants in the case. I call him a 'bull dog' because he resembles one more than anything I can think of. He did not ask me much of anything of importance about what I had testified, but began to attack my character, my knowledge of medicine and surgery, my reputation, and in fact almost everything about me except the legitimacy of my birth. When he had finished I was a nervous wreck

"I have appeared as an expert witness only a few times and had come to be of the opinion that I liked the rôle, but if one must expect to be subjected to that sort of treatment, I am about ready to call off all future appearances in that capacity and hold up my hand and swear, 'Never again'

"Let me have some of your sage advice regarding this at your convenience or save it

until we meet at Atlantic City, if you prefer"

I replied (in part) "If you expect sympathy and condolence from me relative to the abuse you received as told in your recent letter, you are in for a big disappointment because I believe that the expert witness who permits his feelings to become ruffled by the apparent impudence and insults of a cross-examiner is not deserving of sympathy and should never pose as an expert witness at all

"I will say, however, that the attorney who called you to testify should have come to your rescue if the cross-examination and the attacks made upon you were unusual and beyond reason and as bad as you seem to think they were. That was his bounden duty and he was either satisfied with the way you were handling the situation or remiss in not protecting you

"Of course you could have appealed to the judge at any time, if you had felt so inclined. But that, in my opinion, would have appeared as an acknowledgment that you 'could not take it' and might have acted as an incentive and further stimulant to your 'bull dog' to continue his irritation and pestering

"As I look at it, any physician who undertakes to appear as an expert witness should know that it is and will be the part of many of the opposing attorneys to use every possible means to make him out a liar, a knave, or a fool, or a combination of all these, during cross-examination

"If the cross-examiner raises his voice or makes gestures which are apparently intended to intimidate or threaten, or in any way or manner by innuendo or other means to disconcert me—when I am on the witness stand—I have found that a

¹ The Editor desires to state that much of the matter herein because quotations of court proceedings has to be printed in form as received without normal punctuation or phrasing

cent The presence of tumor does not influence the results because, after menopause is established, the tumor atrophies to such extent as to cause no discomfort or inconvenience

The average time required to establish the menopause was six weeks, and the average number of x-ray irradiations in a series was four and a half

The symptoms for which treatment was given had lasted from a few months to twenty years

The range in age was from 13 to 55 years The patient who was only 13 years old had bled excessively at her menstrual periods for more than a year Three curettements had been done and various other treatments, all without success Two efforts were made to bring about relief by producing temporary menopause Permanent menopause was produced after this had failed She is now 25 years old, is perfectly developed and is in good health She had one normal menstrual period a little more than a year ago—the only one since treatment was given The one 55 years old has had twelve children and one abortion Her menses were always normal until she was 50 years of age, when the bleeding became excessive at regular four-week intervals This lasted for three years, then no menses for a year At the time she was treated she had again bled profusely at regular four-week intervals for ten months She has now been entirely well for four years

The general health is almost invariably improved following treatment In no case has cancer developed This may have some significance, since of this number of women in the general population, we might well have expected some to have developed cancer in the pelvis or breast by this time, also because of the established fact that

the production of the menopause retards the growth of some breast cancers, especially those which have metastasized to bone

TECHNIC

In those cases treated with x-ray, we used from 1,200 to 1,800 r, the average amount of treatment being 1,500 r This variation depends upon the age of the patient and also the thickness of the parts This treatment is divided into doses of 300 r given once each week, alternating one anterior and one posterior field

We have used in these cases voltage from 120 kv up to 220 kv and filter from 4 mm of aluminum up to 2 mm of copper At the present time we use 220 kv, 20 ma, 1 mm copper filter, 50 cm distance

In those cases which were treated with radium, we used from 800 to 1,200 mg-hr, the average amount being 1,000 mg-hr We use radium with 1 mm platinum and 1 mm rubber filter

CONCLUSIONS

From a survey of the literature on this subject and from the management and study of this series of cases we reach the following conclusions

(1) That 98 per cent of these patients who have no contra-indications to this method of treatment can be cured by radiation

(2) That this is the most satisfactory method available of handling these cases

(3) That women should not be allowed to suffer discomfort and worse for months or years while establishing the menopause, when by this method of treatment it can be established in from three to six weeks

(4) That there is no permanent bad effect on the sex life resulting from the treatment

(5) That the treatment may help to prevent cancer

Respondeat Superior DID NOT APPLY AND AS PATIENT INSISTED UPON INCREASED DOSAGE HE SPOILED HIS CASE

In a city near Chicago a man 40 years of age had a generalized psoriasis. In addition, he had an area of ringworm on one leg. After having been attended for his psoriasis by a dozen or more physicians he placed his case—especially the ringworm—in the care of a group of physicians who referred him to a roentgenologist in their employ. This latter man has had rather a large experience and knows roentgen therapy pretty well.

The ringworm cleared up promptly under the x-rays, and the psoriatic patches in that region subsided so markedly that the patient insisted upon having x-ray treatment for his psoriasis. This latter condition not progressing as rapidly as the patient thought it should, he insisted upon being given larger doses. The roentgenologist, evidently working on the well-known commercial aphorism that "the customer is always right," administered larger doses, increasing this dosage twice at the behest and insistence of the patient.

Naturally, a point was finally reached at which the tissues could not tolerate the amount of radiation being applied and a flare-up announced the advent of several second degree and a few third degree dermatitic areas.

Then came a malpractice suit, claiming \$50,000 damages. The suit was fought upon its merits and even though it was recognized that the defendants' employee—the roentgenologist—had exceeded the usual and customary dosage, it was brought out clearly and unqualifiedly that the plaintiff had insisted upon the increases of the dosage several times. In cases in which physicians are employed to practise medicine, the employer may not be held for their errors of commission or omission, provided they—the employers—have exercised due care in the selection of duly qualified, licensed physicians.

At the trial of this case, the jury was instructed by the trial judge to bring in a

verdict for the defendants, and so did. The case was then appealed to the Supreme Court of Wisconsin and was there sustained.

This is another instance of a decision that the doctrine or maxim of *respondeat superior* does not apply when physicians are employed by others. However, had the roentgenologist in this case been a member of the group—instead of being an employee—he would have been one of the defendants, and the case would have had to be defended along entirely different lines.

Incidentally, the writer has had experience with two instances wherein the patients insisted upon the application of greater dosage than he personally deemed wise and safe. In one of these, the patient was a physician, and we had the physician-patient write an order—witnessed by his wife and two sons—stating that he insisted upon the administration of three times the usual and normal dosage, and releasing me from any and all liability, blame, or responsibility if damage ensued or resulted.

In the other case, I secured a release in the form published in the sixth installment of the first series of these papers (*RADIOLOGY*, February, 1936, p 161). Fortunately, no bad dermatitis resulted from either of these instances of over-dosage, but if such result had supervened, I feel sure that I was adequately protected and safeguarded. I advise similar action when, as, or if the occasion requires it.

THEY RAN INTO A PARKED AUTOMOBILE

The wife of a banker was riding in her Lincoln phaeton on a forty-foot-wide cement paved highway near Chicago several years ago. She directed her chauffeur to stop at a roadside produce market, and after the automobile had been standing parked in the extreme right side of the pavement for about five minutes, a hard driving, reckless "road hog" drove up from behind, his small light car running into the heavy Lincoln becoming pretty well smashed up. The driver himself was

quiet smile will go farther and do more toward suppressing and disarming such conduct than anything I know that the cross-examiner who begins using such tactics is trying to disturb me and if he finds he can do that he will continue and probably increase the severity of his manner. For that reason I smile at him, partly because I have seen through his ruse, and partly because I know that by my smile I disarm him as surely as if I had tied his hands and then told him to strike me. Menacing gestures are easily left unseen or at least apparently unseen because they never mean anything anyway. Sometimes, when lawyers have persisted in the use of threatening or menacing gestures, I have deliberately turned my head so as not to see them, and once or twice I have calmly closed my eyes. Once after I had so closed my eyes, the lawyer demanded that I look at him, but my reply that he was so repulsive to look at that I preferred not to look at him so disconcerted him that it appeared as though I had turned the tables on him. This attorney immediately returned to his menacing tactics and the attorney who had called me asked the judge to restrain the cross-examiner's action. At that point I remarked, 'Let him continue, your Honor, he does not bother me enough for that.' I was not further molested.

"So taking all into consideration, you must expect to be abused in that way more often than you like, when you appear as an expert witness. School yourself to stand the jibes of the attorneys and learn to develop a thick hide. I have prided myself with having a hide as thick as a rhinoceros while on the witness stand, but I am constantly on the alert and watching for a good opportunity to jab back at the fellow who is trying to take advantage of me. Of course I do not advise being a 'smart Aleck' and trying to show how snappy we can become, but there are times when a carefully worded answer will cut as deeply in the other fellow's hide as he is trying to cut into ours. One of the points that many of our medical expert witnesses ap-

pear to be afraid to answer is a question as to whether they expect to be paid for appearing, and the attorneys frequently try to belittle our testimony—or rather its effect—by giving out the innuendo that our testimony has been bought for just so many dollars. In a recent trial in Western Missouri where I was a witness, I was asked if I expected to be paid. I replied, 'Why certainly I expect to be paid, just the same as you expect to be paid for coming to this trial from K—C—'. The attorney immediately asked that the last portion of my answer be stricken from the record, and it was so 'stricken,' but the jury had my answer, and I could see that I had their sympathy. A similar question asked me in a suit in this city recently was answered 'Yes'. When asked 'How much?' I replied, 'That depends upon how long I am kept from my office.'

"Right here in connection with abusive conduct by attorneys, I am sure that if we hold our heads up and do not become excited or show irritation but maintain our composure under these trying conditions, we elicit and draw out the sympathies of the jury and by such demeanor and behavior do the cause for which we appear much more good than if the nasty behavior had not been brought into play at all. You know that all men and most women sympathize with the 'under dog,' and in such circumstances, where the attorney is applying some of his 'forensics,' the witness who is being abused is 'the under dog'. From my own observations, nearly every time that attorneys pursue such tactics, the other side gets the verdict, so I am inclined to welcome an attack by the 'bull dogs' of the legal profession as you so aptly called your man.

"I wonder if you have read my paper upon 'The Medical Expert Witness,' in the October, 1931, number of RADIOLOGY. I am enclosing a reprint herewith.

"Trusting that you have cooled down by this time and that you are not sore at me for failing to sympathize with you, and for reading this long 'curtain lecture,' I am," etc.

Society on malpractice insurance A short time after the paper was published, he received a letter from a firm of attorneys informing him that if he did not immediately retract certain statements made in that paper they would, in behalf of their clients (naming them), start action for libel against me in the United States District Court

As may be assumed, I was not at all frightened because I had ample proof of everything that had been said about the people and the corporation referred to in the paper and the men named in the letter from the attorneys as the ones who felt aggrieved and who took me to task I had photostat copies of documents, original letters, and plenty of material to prove every statement made in the paper, if proof became necessary

After allowing several days to pass I replied to the attorneys apologizing for the delay in answering and casually asking why their clients had assumed that I had alluded to them in the uncomplimentary statements to which they had apparently taken exceptions I expressed surprise that they had fitted the shoe to their foot if it—the shoe—did not fit I further stated that while no names had been given to the men and institution referred to, I knew to whom the description referred, but that I had not disclosed to any one exactly whom I meant and what individual deserved all the unpleasant things I said The brevity of the letter was excused (it was not at all brief, but I wanted to say something) because of having too much to do to permit of time to carefully consider the matter, and the attorneys were invited to write more fully and in detail, relative to their charges and claims

After a few days, I received a long letter, consisting of several large pages, reciting numerous and various things that the writer was guilty of saying, etc., and threatening in no uncertain terms to have me up before the court

No reply was made to the last-mentioned letter In about a month another letter, enclosing a copy of the previous letter, was received

Thinking that perhaps it might be better to call their bluff at that time, the following was written upon a one-cent post card and sent to the law firm "Relative to the subject of your letters of — and — permit me to say that if you want proof of the truth of every word of my statements in the publication you refer and object to, all you need do is to start the suit you threaten

"I am neither anxious nor desirous of defending any suit, but if forced to such action I not only can but will prove the truth of every word of my allegations"

I heard nothing further regarding the matter But I still have all the proof in my files, ready to use against the individuals, if the occasion ever arises that I might need it

THE LAWYER APOLOGIZED TO THE JUDGE, THE DOCTOR, AND THE JURY

A very well-known and highly respected radiologist who apparently appreciates the writer's efforts along medico-legal lines wrote me in 1929 from which the following is quoted

"I have read with interest your paper 'The Expert Witness Fee' I have just had an experience which I would like to state briefly A few weeks ago I was subpoenaed in my office by a deputy sheriff and ordered to bring all films and records from the B— M— Hospital in a certain case, in a personal damage lawsuit

"The attorney who summoned me is a high pressure ambulance chaser Of course he did it so as to get cheap expert evidence I appeared in court on the day with nothing The district judge asked me why I did not bring the records, as ordered I showed him a copy of a letter from the attorney for the hospital, stating that I could not have the records, that they would be delivered only on subpoena served upon the proper member of the hospital management, namely, the superintendent

"The attorney for the plaintiff immediately despatched his partner to the hospital for the records He went to my technician and wanted to know where the

not injured, but it was alleged that his wife, who was seated beside him, had several bones broken, etc. All this occurred in broad daylight, with the sun shining and on a paved state road, forty feet wide as stated above, a few miles outside of Chicago during the month of September.

The owner and driver of the smaller car brought suit against the owner of the parked Lincoln, alleging numerous and various injuries to both himself and his wife. The writer was called as an expert witness to interpret certain roentgenograms which had been introduced and which had been interpreted as showing two fractured ribs. My testimony was that there were no fractured ribs shown in the films examined by me. Another roentgenologist, of national standing and reputation, testified identically as I had done. In rebuttal the plaintiff introduced a ne'er-do-well physician who claimed to be a roentgenologist. He testified that there were two fractures to be seen in the films.

The case was a frank, open and shut hold-up, but the jury rendered a verdict in favor of the plaintiffs and awarded damages in the sum of \$3,000. The defendant's attorneys moved for a new trial, and in conference with plaintiff's attorneys assured them that they would appeal the case if a new trial was not granted. Thereupon, plaintiff's attorneys offered to settle, and accepted \$1,200 in full for the affair.

Here was an instance in which, in the first place, the defendant's properly parked car was run into by the plaintiff and in which the alleged injuries did not occur, but because the plaintiffs had a plausible, lying, medical expert witness and the defendant was rich and affluent, she had to pay.

INCONVENIENT AND A NUISANCE, BUT WE
WENT JUST THE SAME

About twelve years ago a fine old physician in a small Illinois town on the Mississippi River was sued by the town drunkard for alleged roentgen-ray injury to his hands, following treatment for eczema. The de-

fendant-physician was an old time general practitioner in the small place, where everyone knew and loved him.

The defendant-physician had no malpractice insurance and the State medical society planned to defend him. The Medico-legal Defense Committee asked me to go to the trial as an expert witness for the defense. At my suggestion another radiologist was also asked to go.

Because of the lack of railroad facilities, we were compelled to go into Iowa at night, and cross the Mississippi River back to Illinois in a ferry boat the next morning, and we had to arise long before my usual breakfast time to catch that ferry.

After waiting around the court house for several hours, the trial was started, and after the plaintiff's attorney had presented his case, the attorney for the defendant made a motion that the judge take the case from the jury because the plaintiff had not presented a case. After a few minutes' consideration and deliberation, the judge discharged the jury and gave a verdict for the defendant.

Dr. O. and I had made the trip and had undergone the inconveniences for nothing, but we were nonetheless glad and happy at the outcome. The main and principal compensation we had while waiting for court to open that morning was an opportunity of seeing many flocks of ducks and geese migrating northward up the Mississippi valley.

This case was appealed, and the Appellate Court returned it to the District Court for re-trial, on the basis that there was enough to let a jury decide upon the merits of the plaintiff's claims.

The matter never came up again, as it was settled for a small amount. The good old doctor preferred to settle rather than undergo the inconvenience, annoyance, and disconcerting nuisance of preparing for another trial.

THEY THREATENED TO SUE FOR LIBEL, BUT
THEIR BLUFF WAS CALLED

Quite a number of years ago, the writer presented a paper before the Radiological

Society on malpractice insurance A short time after the paper was published, he received a letter from a firm of attorneys informing him that if he did not immediately retract certain statements made in that paper they would, in behalf of their clients (naming them), start action for libel against me in the United States District Court

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Personally, our reaction to the foregoing recital is that our good colleague gained

considerably thereby. He gained his own self-respect and showed that he merited the respect of the presiding judge.

While this physician did not know it, and the attorneys for the other side of the case probably overlooked it, they in all likelihood could have hidden behind the privileged communication statute in force in that State. It has been decided that hospital records are privileged.

PROSTATIC CARCINOMA ROENTGEN THERAPY DERMATITIS DEATH-SUIT

A firm made up of high type physicians, surgeons, and radiologists treated a 65-year-old man who had carcinoma of the prostate, with apparent success. Some considerable time after the termination of the series of treatments an ulcer developed over the sacrococcygeal region and the man sought the medical advice of a competitor of the firm who had previously treated him.

This competitor—with whom the others had had some minor difficulty—immediately made a diagnosis of 'x-ray burn,' and began daily application of ultra-violet light. The patient succumbed after several weeks, and the man then in attendance secured permission to perform an autopsy, removing (and preserving) the sacrococcygeal region and overlying tissues, and later exhibiting this specimen to the relatives of the dead man. He—it was alleged and probably true—agreed to produce the gruesome pathological specimen in court and testify that the ulcer shown was due to over-dosage with the x-rays. The relatives then brought suit against the firm of physicians, alleging malpractice and asking \$50,000 damages, etc.

After the filing of the suit, one of the defendants, who had somewhere heard about the writer, visited me, accompanied by one of his attorneys, and told the harrowing tale of woe. They gave me the technic that had been used and all the other necessary particulars, and I agreed to take the matter under consideration. After a conference with the insurance company defending the case and several

days' investigation of the conduct of the other physician, I finally agreed to appear as an expert in the case, at the time of the trial of the suit. After making that decision, I wrote the following

"Points to be brought out by my testimony—My qualifications as an expert and an authority in x-ray diagnosis and treatment. Go as far as you like, but make it plenty, so as to impress upon the judge and jury that your witness knows his x-rays

"Treatment by means of the x-rays is recognized as an approved method in cancer of the prostate gland

"The treatment as applied by the defendants (give technic used) was correct and proper treatment for a patient—a man of about 65—afflicted with cancer of the prostate gland, in 1923

"The treatment administered according to the technic stated, should not, and under ordinary conditions would not, produce an x-ray dermatitis, or any other skin reaction or untoward effect upon the patient

"The dose, administered according to the records, is equal to about one-fourth enough to produce a skin reaction

"If a dermatitis (or so-called x-ray burn) did occur, such occurrence was not due to the effect of the x-rays administered by defendants alone, but was probably and in all likelihood due to the application of some irritating or caustic drug or some other agent in addition to the x-rays, or the combination of any two or more of these

"So-called x-ray burns never kill Ultra-violet light treatments may be wrong treatment and contraindicated under some conditions. Authorities differ as to their use during the x-ray treatment period, and some of the best of recent writers deprecate the use of the ultra-violet light as a remedy for x-ray dermatitis. Dr L L MacArthur, a celebrated surgeon of Chicago, who has treated large numbers of x-ray burns, says that ultra-violet light adds insult to injury and does more harm than good. Dr George Miller MacKee, of New York City, one of America's leading

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When the time for the trial arrived, I went to the city where it was to be held, and after a lengthy conference with the defendants and their attorneys and later a conference with the attorneys for the plaintiff, it seemed to me most advisable that this case be settled out of court. With the consent of all concerned, the office of the insurance carrier was reached by long distance telephone, and after a brief conversation they (the insurance carriers) authorized settlement of the suit for \$7,500, and the suit was dismissed.

A few days later, I wrote the following to the insurance carrier: "I had intended writing you yesterday immediately after my return from the scene of that R—vs A— case, but owing to the death of Dr Clarence Geyer, of Milwaukee, I went to that place to attend his funeral, and am therefore a day late in making my formal report regarding that affair at W—

"After looking the situation over, upon my arrival at W— the morning of the 12th, the attorneys, Dr A and Dr B, and I had an extended conference. The doctors were very sure that Dr R would pre-

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"The authorities who recommended the ultra-violet light said that it should be used from once a week to once in three weeks and *not every day as Dr. R used it*

"If no cancer was found in the prostate gland removed at the time of the autopsy as alleged by Dr. R, that does not and cannot prove that cancer had not been present and had been cured by the x-ray treatments. *Unless the entire prostate gland had been sectioned and every microscopic field had been examined under the microscope, it could not be authentically nor authoritatively said that cancer was not present. Any statement to that effect, made under any other condition, would be a guess only, and not reliable. This can be substantiated by all the expert testimony needed to prove its truth.*"

When the time for the trial arrived, I went to the city where it was to be held, and after a lengthy conference with the defendants and their attorneys and later a conference with the attorneys for the plaintiff, it seemed to me most advisable that this case be settled out of court. With the consent of all concerned, the office of the insurance carrier was reached by long distance telephone, and after a brief conversation they (the insurance carriers) authorized settlement of the suit for \$7,500, and the suit was dismissed.

A few days later, I wrote the following to the insurance carrier: "I had intended writing you yesterday immediately after my return from the scene of that R—vs A— case, but owing to the death of Dr. Clarence Geyer, of Milwaukee, I went to that place to attend his funeral, and am therefore a day late in making my formal report regarding that affair at W—

"After looking the situation over, upon my arrival at W— the morning of the 12th, the attorneys, Dr. A and Dr. B, and I had an extended conference. The doctors were very sure that Dr. R would pre-

sent a specimen in the suit, which will show the ulcer on the back, over the region alleged to have been injured by the x-rays. That and other things, particularly the fact that a dermatitis, or what you lawyers have called 'an x ray burn,' probably had been produced, led the attorneys to feel that the case would surely go to the jury. Taking all these items into consideration it was decided best to continue efforts toward settlement, with the result that you, of course, know

"Much as I dislike the idea of settlement of any of these suits, as you know, I think that that was the best and by all means the cheapest way to dispose of this one. The chances that the physician who was behind the entire affair would have made a grandstand play of showing up the gruesome ulcer-bearing anatomical specimen, made it more than ever a bad case to bring to trial."

The physician who aided and abetted the plaintiff in this malpractice suit has passed to his reward—I might have said 'punishment' and not be alone in saying that.

ANOTHER ECZEMA CASE, WITH A BAD END-RESULT

After a conference with the attorney for the insurance carrier of a general practitioner in a northern Illinois city in 1924, I was asked to be present at the trial of a malpractice suit. The suit was for \$15,000 damages, the plaintiff being a woman of that doubtful age between thirty-five and fifty, who had been treated—or perhaps I had better say mistreated—for a chronic eczema on the dorsal surfaces of both hands.

The defendant physician had little or no knowledge of the proper methods of applying the roentgen rays, having had only the instruction of the salesman who sold him the machine, and had produced a third degree dermatitis, which to all appearances was liable to end in considerable deformity and disability.

I was put on the stand to prove that roentgen therapy was an approved and recognized method of treating chronic eczema, that being about all the testimony I could offer which might prove of assistance to the defendant. The defendant's records showed that he had used only moderate dosage, and I testified that the dosage as shown by the records was not excessive. However, the injury was so surely the result of the application of more irradiation than his records showed that my testimony was not nearly as convincing as it would have been under different circumstances, wherein I had had confidence of the correctness of the records. This was so plain that the attorney who represented the State Society afterward joked at my being a "poor dissembler." Had I known more about this case, I would not have attended the trial and would have advised settlement.

The jury brought in a verdict for the plaintiff and fixed the damages at \$3,000, giving a judgment for that amount. The case was finally settled for \$2,200, which was less than I would estimate the amount of damage done.

(To be concluded)

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALIFORNIA

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY *Chairman*, John D Lawson, M D, 1306 California State Bldg, Sacramento, *Secretary*, Karl M Bonoff, M D, 1930 Wilshire Blvd, Los Angeles Meets annually with California Medical Association

LOS ANGELES COUNTY MEDICAL ASSOCIATION, RADIOLOGICAL SECTION *President*, D R McColl, M D, *Vice-president*, John F Chapman, M D, *Secretary*, E N Liljedahl, M D, *Treasurer*, Henry Snure, M D Meets every second Wednesday of month at County Society Building

PACIFIC ROENTGEN CLUB *Chairman*, Raymond G Taylor, M D, 1212 Shatto St, Los Angeles, *Secretary*, L Henry Garland, M D, 450 Sutter St, San Francisco

COLORADO

DENVER RADIOLOGICAL CLUB *President*, W Walter Wasson, M D, 246 Metropolitan Bldg, *Vice-president*, Ernst A Schmidt, M D, Colorado General Hospital, *Secretary*, Nathan B Newcomer, M D, 306 Republic Bldg *Treasurer*, Leonard G Crosby, M D, 366 Metropolitan Bldg Meets third Tuesday of each month at homes of members

CONNECTICUT

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY *Chairman*, Kenneth K Kinney, M D, 29 North Street, Williamantic, *Vice-chairman*, Francis M Dunn, M D, 100 State Street, New London, *Secretary-Treasurer*, Max Climan, M D, 242 Trumbull St, Hartford Meetings twice annually in May and September

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society

FLORIDA

FLORIDA STATE RADIOLOGICAL SOCIETY *President*, Gerald Raap, M D, 168 S E First St, Miami, *Vice-president*, H O Brown, M D, 404 First Nat'l Bank Bldg, Tampa, *Secretary-Treasurer*, H B McEuen, M D, 126 W Adams St, Jacksonville

ILLINOIS

CHICAGO ROENTGEN SOCIETY *President*, David S Beihn, M D, 411 Garfield Ave, *Vice-president*, Chester J Challenger, M D, 3117 Logan Blvd, *Secretary-Treasurer*, Roe J Maier, M D, 7752 Halsted St Meets second Thursday of each month, September to May, except December

ILLINOIS RADIOLOGICAL SOCIETY *President*, Ivan Brouse, M D, 316 W State, Jacksonville, *Vice-president*, Cesar Gianturco, M D, Carle Hospital Clinic, Urbana, *Secretary-Treasurer*, Edmund P Halley, M D, 968 Citizens Bldg, Decatur Meetings quarterly by announcement

ILLINOIS STATE SOCIETY, SECTION OF RADIOLOGY *President*, Roswell T Pettit, M D, 728 Columbus St, Ottawa, *Secretary*, Ralph G Willy, M D, 1138 N Leavitt St, Chicago

INDIANA

INDIANA ROENTGEN SOCIETY *President*, J N Collins, M D, 23 E Ohio St, Indianapolis, *President-elect*, Stanley Clark, M D, 108 N Main St, South Bend, *Vice-president*, Juan Rodriguez, M D, 2903 Fairfield Ave, Fort Wayne, *Secretary-Treasurer*, Clifford C Taylor, M D, 23 E Ohio St., Indianapolis Annual meeting in May

IOWA

THE IOWA X-RAY CLUB Holds luncheon and business meeting during annual session of Iowa State Medical Society

MAINE

See New England Roentgen Ray Society

MARYLAND

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION *Secretary*, H E Wright, M D, 101 W Read St, Baltimore Meetings each Monday night

MASSACHUSETTS

See New England Roentgen Ray Society

MICHIGAN

DETROIT X-RAY AND RADIUM SOCIETY *President*, C C Birkelo, M D, Herman Keifer Hospital, *Vice-president*, E W Hall, M D, 10 Peterboro St, *Secretary-Treasurer*, E R Witwer, M D, Harper Hospital Meetings first Thursday of each month from October

to May, inclusive, at Wayne County Medical Society Bldg

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS *President*, J C Kenning, M D, 1536 David Whitney Bldg, Detroit, *Vice-president*, A W Chase, M D, 133 Toledo St, Adrain, *Secretary-Treasurer*, C S Davenport, M D, 609 Carey St, Lansing

MINNESOTA

MINNESOTA RADIOLOGICAL SOCIETY *President*, Walter H Ude, M D, 78 S 9th St, Minneapolis, *Vice-president*, Leo G Rigler, M D, University Hospitals, Minneapolis, *Secretary-Treasurer*, Harry Weber, M D, 102 Second Ave, S W, Rochester Meetings quarterly

MISSOURI

THE KANSAS CITY RADIOLOGICAL SOCIETY *President*, L G Allen, M D, 907 N 7th St, Kansas City, Mo, *Secretary*, Ira H Lockwood, M D, 306 E 12th St, Kansas City, Mo Meetings last Thursday of each month

THE ST LOUIS SOCIETY OF RADIOLOGISTS *President*, Joseph C Peden, M D, 634 N Grand Blvd, *Secretary*, W K Mueller, M D, 607 N Grand Blvd Meetings fourth Wednesday of each month

NEBRASKA

NEBRASKA STATE RADIOLOGICAL SOCIETY *President*, Howard B Hunt, M D, 4740 Hickory St, Omaha, *Secretary*, D Arnold Dowell, M D, 117 S 17th St, Omaha Meetings first Wednesday of each month at 7 P M in Omaha or Lincoln

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut) *President*, Frank E Wheatley, M D, 520 Beacon St., Boston, *Secretary*, E C Vogt, M D, 300 Longwood Ave, Boston Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library

NEW HAMPSHIRE

See New England Roentgen Ray Society

NEW JERSEY

NEW JERSEY STATE RADIOLOGICAL SOCIETY *President*, W W Maver, M D, 532 Bergen Ave, Jersey City, *Vice-president*, J D Tidaback, M D, 382 Springfield, Summit, *Secretary*, P S Avery, M D, Middlesex Gen-

eral Hospital, New Brunswick Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by President.

NEW YORK

BROOKLYN ROENTGEN SOCIETY *President*, Albert Voltz, M D, 115-120 Myrtle Avenue, Richmond Hill, *Vice-president*, A L L Bell, M D, Long Island College Hospital, Henry, Pacific, and Amity Sts, Brooklyn, *Secretary-Treasurer*, E Mendelson, M D, 132 Parkside Ave, Brooklyn Meetings first Tuesday in each month at place designated by president

BUFFALO RADIOLOGICAL SOCIETY *President*, John Barnes, M D, 875 Lafayette Ave, *Vice-president*, W L Mattick, M D, 290 Highland Drive, *Secretary-Treasurer*, J S Gian-Franceschi, M D, 610 Niagara Street. Meetings second Monday evening each month

CENTRAL NEW YORK ROENTGEN-RAY SOCIETY *President*, W E Achilles, M D, 60 Seneca St, Geneva, *Vice-president*, M T Powers, M D, 250 Genesee St, Utica, *Secretary-Treasurer*, Carlton F Potter, M D, 425 Waverly Ave, Syracuse Meetings held in January, May, and October as called by Executive Committee

LONG ISLAND RADIOLOGICAL SOCIETY *President*, David E Ehrlich, M D, 27 W 86th St, New York City, *Vice-president*, H Koiransky, M D, 43-37 47th St, Long Island, *Secretary*, S Schenck, M D, 115 Eastern Parkway, Brooklyn, *Treasurer*, Moses Goodman, M D, 45-01 Skillman Ave, Long Island Meetings third Thursday evening each month at Kings County Medical Bldg

NEW YORK ROENTGEN SOCIETY *President*, E F Merrill, M D, 30 W 59th St, New York City, *Vice-president*, I W Lewis, M D, *Secretary*, H K Taylor, M D, 667 Madison Ave, New York City, *Treasurer*, R D Duckworth, M D, 170 Maple Ave, White Plains Meetings third Monday evening each month at Academy of Medicine

ROCHESTER ROENTGEN-RAY SOCIETY *Chairman*, Joseph H Green, M D, 277 Alexander St, *Secretary*, S C Davidson, M D, 277 Alexander St Meetings at convenience of committee

SOCIETY OF RADIOLOGICAL ECONOMICS OF NEW YORK. *President*, Albert L. Voltz, M D, 115-120 Myrtle Ave., Richmond Hill, *Vice-president*, M. M. Pomeranz, M D, 911 Park Ave., New York City, *Secretary*, W. F. Francis, M D, *Treasurer*, Theodore West, M D, United Hospital, Port Chester. Meetings first Monday evening each month at McAlpin Hotel.

NORTH CAROLINA

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *President*, Robert P. Noble, M D, 127 W. Hargett St., Raleigh, *Vice-president*, A. L. Daughtridge, M D, 144 Coast Line St., Rocky Mount, *Secretary-Treasurer*, Major I. Fleming, M D, 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

RADIOLOGICAL SOCIETY OF THE ACADEMY OF MEDICINE (Cincinnati Roentgenologists). *President*, George Benzeng, M D, St. Elizabeth Hospital, Covington, Ky., *Secretary-Treasurer*, Justin E. McCarthy, M D, 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

PENNSYLVANIA RADIOLOGICAL SOCIETY. *President*, Sydney J. Hawley, M D, Geisinger Memorial Hospital, Danville, *First Vice-president*, William J. McGregor, M D, 744 Franklin Ave., Wilkesburg, *Second Vice-president*, Oscar M. Weaver, M D, 12 S. Main St., Lewistown, *Secretary-Treasurer*, Lloyd E. Wurster, M D, 416 Pine St., Williamsport, *President-elect*, Charles S. Caldwell, M D, 520 S. Aiken Ave., Pittsburgh. Annual meeting, May, 1938. Exact date and place to be decided.

PHILADELPHIA ROENTGEN RAY SOCIETY. *President*, Thomas P. Laughery, M D, Germantown Hospital, *Vice-president*, Elwood E. Downs, M D, Jeans Hospital, Fox Chase, *Secretary*, Barton H. Young, M D, Temple University Hospital, *Treasurer*, R. Manges Smith, M D, Jefferson Hospital. Meetings

first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S. 22nd St., 8:15 P. M.

RHODE ISLAND

See New England Roentgen Ray Society

SOUTH CAROLINA

SOUTH CAROLINA X-RAY SOCIETY. *President*, Robert B. Taft, M D, 105 Rutledge Ave., Charleston, *Secretary-Treasurer*, Hillyer Rudisill, M D, Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

MEMPHIS ROENTGEN CLUB. Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

TENNESSEE STATE RADIOLOGICAL SOCIETY. *President*, H. S. Shoulders, M D, 246 Doctors Bldg., Nashville, *Vice-president*, S. S. Marchbanks, M D, 508 Medical Arts Bldg., Chattanooga, *Secretary-Treasurer*, Franklin B. Bogart, M D, 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

VERMONT

See New England Roentgen Ray Society

VIRGINIA

RADIOLOGICAL SOCIETY OF VIRGINIA. *President*, Fred M. Hodges, M D, 100 W. Franklin St., Richmond, *Vice-president*, L. F. Magruder, M D, Raleigh and College Aves., Norfolk, *Secretary*, V. W. Archer, University of Virginia Hospital, Charlottesville.

WASHINGTON

WASHINGTON STATE RADIOLOGICAL SOCIETY. *President*, H. E. Nichols, M D, Stimson Bldg., Seattle, *Secretary*, T. T. Dawson, M D, Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

PRIMARY CARCINOMA OF THE LUNG

There are many to-day who feel that bronchogenic carcinoma is increasing in frequency. It is difficult to determine whether this increase is absolute or relative, but it is a fact that the early recognition of the disease has enormously increased. This earlier recognition has resulted largely from the combined efforts of the roentgenologist and bronchoscopist working as a diagnostic team.

No common etiologic factor has been found to account for the occurrence of the disease. It has been found somewhat more frequently in association with pneumoconiosis, but it may occur in an otherwise healthy person. It is common among cobalt miners of Schneeberg and also among pitch-blende miners of Austria. Martland (1) believes this to be due to inhalation of the radio-active ore whereby the alpha particles come in direct contact with the tissues causing atomic and molecular disintegration. This action of the alpha particle is much more destructive than either the beta or gamma rays.

The incidence of carcinoma of the lung varies from 5 to 10 per cent of all malignancy. Rose-dale and McKay (2) report 7.5 per cent from Buffalo City Hospital, and Brines and Kenning (3) report 7.8 per cent from all cases of carcinoma found in Detroit Receiving Hospital.

It is probably the second or third most common form of malignancy found at autopsy. Males are much more frequently affected than females. The most common symptoms are cough, pain in the chest, dyspnea, loss of weight, and hemoptysis.

It is said to be somewhat more common in the right lung. The typical location of these tumors is in the larger bronchi near the hilus, but occasionally they begin in the smaller more peripheral bronchi. In a few cases there appears to be a diffuse infiltration of the parenchyma of the lung.

Bronchogenic carcinoma is notable for its widespread metastases to the skeletal system and most of the other organs. It is especially

prone to metastasize to the liver, kidney, adrenal, contralateral lung, and brain. Regional and distant lymph glands are usually involved. In some instances the primary tumor is inconspicuous in comparison with its more prominent metastases.

For early diagnosis reliance must be placed on bronchoscopy and the roentgen-ray examination. Clerf (4) states that bronchoscopy is the most definite and positive diagnostic procedure available. This is, however, limited to growths of the larger bronchi. The diagnosis by bronchoscopy depends upon direct endoscopic view of the growth, biopsy, and secondary changes in the bronchial wall. Fixation and rigidity of the bronchial wall indicate infiltration even when no tumor tissue is visualized.

Farrell (5) states that evidence of pulmonary atelectasis is the most common roentgenographic finding and was found in 40 per cent of his cases. Visualization of the tumor mass and secondary congestive lung changes from the obstructing tumor were important findings. Cavitation in the tumor is not uncommon and can be readily detected on the roentgen film.

Until recent years these cases have been detected so late in the course of the disease that palliation only could be attempted. At the present time radiotherapy and surgery are the accepted methods of treatment. The latter is used in selected cases where there is a fair chance of complete removal of the tumor either by lobectomy or complete pneumonectomy. Surgical diathermy is also used perorally.

One case in which lobectomy was performed was reported by Allen (6). The patient lived more than four years, but recurrence in the stump was present after two and one half years. Radiotherapy kept this in check until the patient died of pneumonia. Overholt (7) reported a similar case, with death after ten months.

Complete pneumonectomy has been carried out with increasing frequency during the past few years. In 1933 Graham and Singer (8) performed a complete pneumonectomy for carci-

noma, with recovery of the patient Two years later Graham (9) reported the patient to be well at that time Overholt (7) reported two cases in which the patients were alive and well 14 and 20 months later, respectively Allen has one unreported case that is well one year after complete pneumonectomy for primary carcinoma

The surgical mortality from lobectomy or pneumonectomy in the past has run from 20 to 30 per cent In a series of 35 cases collected from the literature by Carlson and Ballon (10) there were 15 deaths or 43 per cent, shortly after lobectomy or pneumonectomy It is only fair to state, however, that the operative mortality has been steadily decreasing in recent years

It should be kept in mind that occasionally the tumor is of such small size and is located in the main bronchus so that it can be removed by cauterization through the bronchoscope Radon seeds can be implanted following the surgical procedure

Many of these tumors have proven relatively radioresistant but the results are far from hopeless In many instances it results in prolongation of life and gratifying symptomatic relief Manges (11) reported three of his cases living and well six, seven, and eight years, respectively, after roentgen therapy, and several others more than one year Leddy and Vinson (12) had 10 patients who received roentgen therapy for proven bronchogenic carcinoma These patients were living from 15 months to four years later, with an average duration of life of 23 months These cases constituted 25 per cent of their entire series Kernan (13) observed nine cases of proven carcinoma which were treated by means of x-ray, radium implantation, and surgical diathermy All but one of these cases were treated by means of surgical diathermy and the implantation of radon seeds The other one received radon, x-ray, and diathermy Three patients were dead, four were alive and well, and two were alive but had suggestive shadows in the chest All of these patients were living from two to five years after radiotherapy and diathermy

It should be noted that radiotherapy is applicable in nearly all cases of bronchogenic carcinoma and is palliative in those cases in which a cure is not obtained There is no mortality associated with this therapeutic procedure From a critical study of the therapeutic possibilities in this disease it is apparent that radiotherapy occupies an important place in its control Radical surgery is more dramatic, but

has a considerable associated mortality and is applicable in comparatively few cases

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HOWARD P DOUB, M D

TO THE MEMBERS OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

This year the Annual Meeting of your Society will be held at the Palmer House, Chicago, September 13-17, in conjunction with the Fifth International Congress of Radiology The regular scientific program of our Society has been omitted this year in order to permit the members to enjoy to the utmost the comprehensive scientific discussions and exhibits that have been arranged by the Congress The officers of the Fifth International Congress of Radiology have spared no effort to make this assembly one of the outstanding radiologic conferences of all time and many unusual educational opportunities will be available to you at this meeting

Through the co operation of the officers of the Congress generous provision has been made for the necessary business sessions of the Radiological Society of North America. All of these have been scheduled at a time which will not interfere with the scientific program. A luncheon for the members of our Society will take the place of the usual Counsellors' dinner, and I hope that all of you will plan to attend this important event. Thursday evening has been set aside for the formal functions of the Radiological Society of North America. Following the annual banquet, at which your Society will be host to the officers of the American and foreign radiological societies, we shall adjourn to the grand ballroom where Doctor George Winslow Holmes, Clinical Professor of Roentgenology at Harvard Medical School, will deliver the Fourth Carman Lecture on the subject, "The Development of Post-graduate Teaching in Radiology." At the conclusion of the Carman Lecture a reception for Doctor Holmes, and dancing, will complete the program which has been arranged for our members.

Throughout the existence of the Radiological Society of North America our meetings have been noted for their scientific excellence and spirit of good fellowship. This year, through the unusual facilities afforded by the Fifth International Congress of Radiology, it will be our rare privilege to share these with our American and foreign colleagues. I sincerely hope that I may have the pleasure of greeting all of you in Chicago.

JOHN D. CAMP, M.D., *President*

ANNOUNCEMENT

FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

PALMER HOUSE, CHICAGO

September 13-17, 1937

Attendance at this International Congress is not limited to members. A registered guest of the Congress is entitled to enjoy all of the features that have been provided. A registered guest may attend and take part in the discussion at any of the scientific meetings along with the regular members and he is at

liberty to visit all of the exhibits with full privileges. Registration for an educational course will require a small additional fee. To attend the grand banquet, he will be required to purchase a ticket for same at the registration desk.

Members who have delayed forwarding their data until they could not be included in the Portrait Catalogue will receive all of the privileges accorded members, including a copy of the Portrait Catalogue.

For registered guests of the Congress, the fees are as follows: Registration for the entire Congress, \$10.00, registration for one day, \$3.00, registration for one complete educational course, \$4.00, registration for an educational course, single day, \$1.00, portrait catalogue for guest, \$8.00, portrait catalogue, post-congress, \$10.00.

To facilitate the work of the committees who are providing entertainment features for the Congress, it is very important that members and registered guests notify the Secretariat as early as possible if they desire to register an Associate Member. If the members and guests of the Congress neglect the registration of their associate members until they come to the Congress, the Committees will make every effort to provide for this group, but it is evident that if the numbers registered late are not exceedingly small, it will become very disappointing to both the Associate Member and the Committee.

The Reception to Foreign Guests, sponsored by the Chicago Roentgen Society, on Sunday afternoon from 3 until 6 o'clock, September 12, becomes the first opportunity for the American radiologists to greet their colleagues from foreign lands. The Congress desires to co operate with the Chicago Roentgen Society in every possible way in making this reception a very pleasant occasion. Members of the Congress should make an effort to be present and to enjoy this most unusual opportunity.

Group dinners, whereby the American radiologists may have the opportunity to be hosts to a selected group of their friends from home and abroad, are being organized for the Sunday evening following the afternoon reception. Some of our radiologists have already requested arrangements for their dinners. The Chairman of the Committee of Reception to Foreign Guests is anxious to assist in these arrangements. The Committee will endeavor to sup-

ply one or more foreign guests for any dinner upon request, and they will also co-operate in securing the foreign guests who may be designated by the host giving the dinner

The Scientific Program has been completed. Some of the arrangements are new and unique, and it is probably the first time that an attempt has been made to present an international program whereby the leaders in the science of radiology from all of the various countries of the world will present their contributions in such a way that they will be understood without difficulty by everyone in attendance. Three hundred contributions are grouped in nine sections. They are so classified that the members and guests of the Congress will be able to arrange their schedule conveniently, wherein they may attend and hear the contributions covering the latest developments in the phases of radiology in which they are most interested.

The Scientific Exhibits have been arranged with utmost care. The magnitude of this display would seem entirely too great were it not for the fact that the Committee has endeavored to group the material in such a way

that topical study may be undertaken. The Congress will recognize the excellence of this work by conferring its scientific awards. The effort that has been given to the organization of this exhibit insures its high character and usefulness to everyone in attendance.

The Educational Courses have proven to be very popular with the members. While it is possible to accommodate a fairly large number in each of these courses, some have almost reached their limit, while others may receive several more before reaching their full quota. It is hoped that such registration will be requested as early as convenient in order that the confusion of last minute arrangements may be avoided.

Members who are unable to reach Chicago for the Reception of Foreign Guests on Sunday afternoon should not fail to be present and attend the Opening Exercises on Monday evening. Those who have not attended these occasions at international congresses should make every possible effort to be present.

The registration desk will open officially at 1 o'clock on Sunday afternoon, September 12, 1937.

COMMUNICATION

THE AMERICAN RADIUM SOCIETY

OFFICERS AND COMMITTEES, 1937-1938

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ABSTRACTS OF CURRENT LITERATURE

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S M ATKINS M D, of Waterbury, Conn	ERNST A POHLE M D Ph D of Madison, Wis
S RICHARD BEATTY, M D, of Madison Wis	CHARLES G SUTHERLAND, M B (Tor) of Rochester, Minn
L G JACOBS M D of Madison Wis	
DAVIS H PARDOLL M D of Chicago Ill	

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ANIMAL EXPERIMENTATION

Histologic Changes in the Eye of the Rabbit Following Intra-ocular Injection of Radium Chloride Solution
F Eichbaum *Strahlentherapie* 1937, 59, 90

In 1933, Altschul recommended the injection of small amounts of radium solutions into the eye in order to study the biologic effects of radium (*Strahlentherapie* 1935, 53, 187). He suggested 1 mc as the minimum quantity. The author conducted similar experiments and studied the changes in the eye histologically at four weeks following the injection, and in one case four months later. He found that 0.5 mc produces mild inflammatory changes while from 1 to 1.5 mc causes rather destructive processes. He recommends therefore, to reduce the usual quantity for experiments of this type to 0.5 mc.

ERNST A. POHLE, M.D., Ph.D.

Experiments to Determine the Roentgen Resistance of the Virus of the Contagious Leukosis of Chicken E Forfota *Strahlentherapie*, 1937, 59, 83

The author irradiated the virus of the contagious chicken leukemia with roentgen rays *in vitro* (150 kv at, 4 ma, 20 cm FSD, no filter, HED = 550 r). It appeared that the virus was absolutely resistant and showed no changes even after doses of 200 HED. The author concludes, therefore, that in all probability the virus is not a living organism but a product of the leukemia cells.

ERNST A. POHLE, M.D., Ph.D.

APPARATUS

Teleradiography and the Compass of Hertz Viallet and Jalet *Bull. et Mém. Soc. Radiol. Méd. de France* February, 1937, 25, 166-169

In conjunction with roentgenograms taken at a distance (3 meters), the compass of Hertz furnishes a convenient and exact means of localizing foreign bodies.

S. RICHARD BEATTY, M.D.

ARTERIOGRAPHY

Arteriography of Changes in Cerebral Vessels in *Comotio and Contusio Cerebri* W. Löhr *Zentralbl. f. Chir.*, Nov. 7, 1936, 63, 2642-2653 (Reprinted by permission from *British Med. Jour.*, Dec. 26, 1936, p. 108 of *Epitome of Current Medical Literature*.)

W. Löhr discusses the value of arteriography in cranial injuries. In cerebral concussion and in the more serious cerebral contusion the arteriography shows in cases of milder injury a contraction of blood vessels. The picture resembles the one seen, for example, in hydrocephalus. In grave cases and in the presence of cerebral tumefaction the blood vessels fill incompletely and are flattened owing to vascular

paralysis and to mechanical compression. There is also more resistance to the inflow of the thorotrast during the injection. Incidentally this increased resistance is observed whenever the intracranial pressure is increased. The differential diagnosis between meningeal hemorrhage and cerebral concussion or contusion can be made from the respective arteriographic appearances. In cerebral compression through meningeal or subdural hemorrhage the brain is displaced. The arteriographs therefore resemble those seen in tumors of the temporal lobe or in otogenic abscesses. But whereas in tumors, abscesses and meningeal hemorrhage the vessels are pushed away from the inner cranial wall in concussion or contusion the appearance is different. The vessels are not displaced at all, or only very slightly. In concussion they appear contracted, but remain in their normal position. There is also a slight peripheral stasis. In contusion laceration and tumefaction of the brain the vessels, even the smallest, are flattened as a result of the increased pressure and their filling is incomplete. The paralysis and the narrowing of the vessels are caused by the swollen brain which compresses the vasomotor nerves and flattens the vessels. Arteriography is valuable in the severe and neurologically difficult cases when applied early because the discovery of a cerebral compression is useful to the surgeon only in its early stages. When the decompression is delayed the compressed brain will not re-expand in spite of the removal of the clot.

Dangers of Arteriography E. Verschuyt *Nederl. Tijdschr. v. Geneesk.*, March 6, 1937, 81, 1007-1012 (Reprinted by permission from *British Med. Jour.*, May 8, 1937, p. 74 of *Epitome of Current Medical Literature*.)

The author who records two personal cases, states that in spite of the statements made by Reynaldo dos Santos in 1933 and by Leriche in 1935 arteriography is liable to lead to serious complications. These have been recorded chiefly by French writers and may be divided into two groups. The first consists of a livid discoloration of the skin with peculiar violet spots which later become gangrenous as recorded by Lambert, Matthieu, Leveuf, Deplat and Reboul. The second group consists of gangrene without a transitional stage of discoloration of which examples have been recorded by Leclerc, Moniz and Reboul. Verschuyt's first case was that of a man aged 70 who was admitted to hospital for violent pain in the left leg which was pale and cold. There was a history of slight attacks of pain in the leg for the last ten years. The aorta was punctured at the level of the third lumbar vertebra and 20 c.c. of 35 per cent perabrodil was injected. The arteriograph showed an obstruction of the arteries on the right side below the common iliac artery. Death took place suddenly the following day. At necropsy the pericardial sac was found to be filled with large blood clots owing to rupture of the ascending aorta and there was an extensive retroperitoneal

hematoma No rupture could be observed in the abdominal aorta, and Verschuyt attributes the hematoma to puncture of the aorta The second case was that of a woman aged 28, admitted to hospital for severe pain in the right arm accompanied by cyanosis and swelling Arteriography was performed by the injection of 20 c.c. of perabrodil into the right subclavian artery Immediately after the injection the patient had a typical epileptic attack, but rapid recovery took place The arteriograph showed nothing abnormal

THE BREAST (BENIGN)

Mastitis W T Wiemer München med Wchnschr, Jan 22, 1937, pp 132-133 (Reprinted by permission from the British Med Jour March 27 1937, p 50 of Epitome of Current Medical Literature)

The author believes that most cases of mastitis occur because early symptoms are neglected or inadequately treated Any fissure around the nipples should be sprayed with 10 per cent novacain and then cauterized with 10 per cent silver nitrate A sterile dressing is then applied Milk is pumped off for three days, when the child is suckled again In the presence of inflammation deep x ray therapy is administered on three consecutive days The temperature falls at once, and pain is relieved If there is any infiltration it is irradiated with a Sollux lamp daily until it disappears Early treatment is essential There is little hope of success in a mastitis of two days' duration In the author's experience Bier's suction pump does not give nearly as good results as deep x ray therapy When an abscess forms it is not opened until definite fluctuation occurs It is then incised with the thermocautery The incision is as small as possible In large abscesses two or three incisions may be necessary The cavity is then washed out with antiseptic lotion The small incision gives a good cosmetic result Its edges do not heal rapidly and therefore no drainage tube is necessary Bier's suction pump may be used in the after treatment to evacuate the abscess painlessly and to enable the cavity to heal more quickly on account of the hyperemia produced Wiemer in a large series of cases has never seen any untoward results from deep x ray therapy It does not affect the milk secretion and the irradiated milk does not harm the child The rapid relief of pain enables the mother to suckle her child without fear of recurrence

BREAST CANCER

An Evaluation of the Roentgen Diagnosis of Early Carcinoma of the Breast Jacob Gershon Cohen and A P Collier Jour Am Med Assn, March 13, 1937 108, 867-871

While it is difficult to credit some of the recent enthusiastic reports on the roentgen examination of the breast which seem almost tantamount to histologic

studies the high percentage of roentgen interpretations that were confirmed by microscopic examination of the tissue is remarkable

Serial roentgenographic studies of the normal breast in women past the age of 25 is so simple a procedure and economically practicable that it is worthy of serious consideration as a measure to be taken now in the control of mammary cancer

The least number of errors in the roentgen diagnosis of malignant mammary tumors was made in the atrophic breasts, most of which occur in the fifth and sixth decades, usually at or after the menopause In these breasts the single examination has already exhibited its diagnostic possibilities for accuracy The chief reason for this is the clear visibility of the tumor margins afforded by the homogeneous fat content of the breast the fat being a good radiolucent contrast medium It is often surprising how easily discernible are the striations of malignant infiltrations radiating from the margins This is partially true also when there is excessive fat infiltration in the active breast of the younger individual

Deep seated nodules are found more easily by the roentgen examination than by palpation

CHARLES G SUTHERLAND, M B (Tor)

CANCER (THERAPY)

Experience in the Radiotherapy of Malignant New-growths of the Upper Air and Food Passages Hans R Schinz and A Zuppinger München med Wchnschr, April 9, 1937 84, 561-564

After a rather lengthy review of cancer statistics in Switzerland, the authors point out that the only methods of curing cancer are surgery and irradiation, and that the cures depend on early suspicion early diagnosis and early treatment They feel that oral carcinoma has ceased to be hopeless and that surgery has fallen into disrepute in this form of cancer because of the severe mutilation, although as electrocoagulation it has regained something of its old role The main standby is radiotherapy either as external x radiation as radium interstitially, or applied in intracavitary applicators, and as telerradium therapy This implies great advances in radiation therapy in the last fifteen years Its progress consists of the correlation between histology and the course planned and of knowledge of the significance of optimum time factors for the production of reactions, and of the clinical care with hospitalization and modification of the course with the patient's tolerance and the local reaction

Most of their patients come too late for local radium treatment, and they depend on protracted fractional x-ray treatment The dose is large enough to produce an exudative and fibrinous epithelitis with epithelial desquamation

The two groups (1919-1928, 1929-1935) show that the latter was larger and included a further advanced group of patients The percentage of operable cases is only half as great Primary healing occurred in 47 per

cent in the first period, in 71 per cent in the second 19 per cent and 31 per cent were well for three years 17 per cent and 22 per cent for five The average life of patients who later died was eight years nine and one-tenth months The authors feel that this is definite proof of the advantage of the protracted fractional method They summarize their plan of treatment and again emphasize the need for early care, they feel that there is prospect of further advance in the future perhaps through increases in voltage or telerradium therapy

(The abstractor notes that the difference between the five year results is not beyond the range of chance variation, being approximately two sigma only However the three year results are beyond the range of likely chance variation This suggests that the improvement is not so much in curability as in better palliative relief)

L G JACOBS M D

Surgery and Radiation Therapy in the Treatment of Malignant Tumors L. Schönbauer Strahlentherapie, 1937, 58, 632

The author stresses the importance of close co-operation between surgeon and radiologist in the treatment of malignant disease For some tumors, i.e. those in the gastro intestinal tract, genito-urinary system breast, and brain, he recommends operation In a table he has compiled data on three year survivals comparing 326 patients treated surgically during a period of 20 years and 292 patients treated by irradiation over a period of five years They include carcinoma of the tonsil, cheek palate, mouth, and tongue The relative percentage of survival at the end of three years was 31 for the surgical group and 38 for the radiological group

ERNST A. POHLE M D, Ph D

Combined Radium and Roentgen Therapy of Carcinoma of the Rectum and Anus R. Niedermayr Strahlentherapie, 1937, 58, 624

The author recommends combined treatment of rectal carcinoma by roentgen rays and radium Inoperable cases may be rendered operable by proper irradiation If surgical excision of the rectum is impossible operative exposure of the tumor followed by thorough radium irradiation may lead to unexpected remissions Several illustrative case reports are appended

ERNST A. POHLE M D Ph D

The Treatment of Urethral Carcinomas R. Volbracht Zentralbl. Gynäk. Dec 12 1936 60, 2946-2957 (Reprinted by permission from British Med Jour March 27 1937 p 52 of Epitome of Current Medical Literature)

According to the author collected statistics concerning carcinoma of the urethra are few but suffice to show a bad prognosis both from surgical and radiological therapy The former has a cure rate of some 3 to 5 per cent and is suitable only for growths in the earliest possible stages Radiotherapy encounters equal ana-

tomical difficulties, but a series of 14 cases from the Berlin Universitäts-Frauenklinik showed a five year survival in five, these comprised four of vulvo-urethral and one of peri urethral carcinoma, no case of purely urethral growth surviving

The treatment at present carried out is radium application to the primary growth, followed by γ radiations and block dissection of the inguinal glands Too heavy a dosage of radium leads to stenoses and fistulae not more than 2 000 mg-hr is recommended, and preferably half that dose For the most frequent (the vulvo-urethral) form Volbracht advises against placing radium in the urethra, six or seven radium needles are inserted around and parallel to the urethra and over the tumor or ulcer is temporarily sutured a disk shaped carrier of seven more radium needles which is perforated centrally for insertion of a rubber catheter A series of seven further cases is here described—three purely urethral and four vulvo-urethral Two are still under treatment, one has remained for seven months free of recurrence, the rest on the average died within a year

THE COLON

Two Cases of Hepato-diaphragmatic Interposition of the Colon Autopsy Reports Choussat and Choussat-Clausse Bull. et Mém. Soc. Radiol. Med. de France February 1937 25, 147-154

Two cases of interposition of the colon which developed during continued observation of the patients are presented and the autopsy findings given

In one case of cavernous pulmonary tuberculosis interposition of the colon was probably due to liver atrophy In the other case of long continued pyloric hypertrophy and stenosis a groove on the surface of the right lobe probably congenital allowed the colon to ascend

In a discussion of the etiology of this condition the authors tabulate first conditions concerning the liver, modifications in volume, mobility and form second deficiencies and distensions of the diaphragm and third such factors as gas distended colon mega and dolichocolon relaxations of the colonic fixations, and abnormalities of the mesentery

S. RICHARD BEATTY M D

THE COUTARD METHOD

Roentgen Therapy of the Pelvis in the Treatment of Carcinoma of the Cervix Henri Coutard Am Jour Roentgenol and Rad Ther November 1936 36, 603-610

This paper is but a brief summary of the Stage III carcinoma extensive invasion of both parametria reaching the wall of the pelvis and of a number of extensive recurrences after operation at the Institut du Radium of Paris University between 1919 and 1929

With the method now employed the five year sur-

vival ratio is 36 per cent This is larger than has ever before been attained

The method consists of the application of small amounts of radiation per minute and per day over a period of from five to seven weeks, until 10,000 to 14,000 r have been administered over the pelvis It is this protraction of the treatment, coupled with the low intensity and small amount of r per day, which has permitted the large total dose and the improvement in results without the bad general radiation effects

The number of portals used were at least six, two latero-sacral, two ilio-inguinal, and two gluteal, and these were treated in rotation The associated treatments have usually commenced with roentgen rays with radium subsequently, the dose being about 20 per cent larger when roentgen therapy is used alone Except in the latter group the rays have been directed chiefly to the parametria For small patients all the factors must be decreased Patients weighing over 70 kg show poorer results owing to the ineffective dose especially if roentgen radiation alone is employed

The entire article should be read

S M ATKINS, M D

THE EAR (MIDDLE)

Middle Ear Diseases W Loepp Med Klinik Oct 30, 1936, pp 1496, 1497 (Reprinted by permission from British Med Jour, Dec 26, 1936 p 99 of Epitome of Current Medical Literature)

The author presents the following points in favor of roentgenographic examination in diseases of the middle ear the roentgenograph gives us a general idea of the structure and topography of the temporal bone of the degree of its pneumatization of the position and condition of the antrum, of any possible developmental anomalies of the os tympanicum, etc A mastoiditis can be demonstrated roentgenographically before the onset of clinical symptoms and the different stages of its evolution can be followed on successive roentgenographs Occasionally grave complications of mastoiditis such as a perisinus abscess can be demonstrated before the appearance of their clinical manifestations The roentgenographic examination may be able to elicit the cause of recurrences after an operation It may demonstrate a cholesteatoma and its complications when other clinical methods have failed to establish a diagnosis It may reveal the carcinomatous or tuberculous nature of a chronic middle-ear suppuration On the other hand the roentgenographical examination may fail for the following reasons it is often impossible to distinguish roentgenographically between defective pneumatization and slight inflammatory changes in the mastoid, the roentgenographical demonstration of a mastoiditis is irrelevant for the prognosis, as a mastoiditis may heal spontaneously under conservative treatment, in the presence of certain clinical complications in mastoiditis an operation is indicated in spite of the absence of anatomical changes on the roentgenograph

ENCEPHALOGRAPHY

Encephalography by the Lumbar Route in the Child R Mathey-Cornat and J Dupin Jour Radiol Electrol, November, 1936, pp 597-606 (Reprinted by permission from British Med Jour, Jan 30 1937 p 19 of Epitome of Current Medical Literature)

The authors point out the diagnostic and therapeutic importance of encephalography through the lumbar route in children As a diagnostic procedure it supplied information on the disposition of the cerebral ventricles, on the permeability of the subarachnoid spaces, on the circulation of the cerebro spinal fluid etc, in mental defectives, idiots, microcephaly epilepsy, hydrocephaly, meningeal syndromes, and paralysis of childhood The only contra-indication is the suspicion of a cerebral or cerebellar tumor in the posterior cranial fossa From the therapeutic point of view the procedure has proved useful in cerebro-spinal meningitis and in epilepsy It is probably also beneficial in a number of other conditions, such as post traumatic sequelae to cranial injuries, post-traumatic epilepsy etc In children the injection of 15 to 20 c c of air is sufficient for most therapeutic purposes The radiographic images obtained with these small quantities of air are satisfactory in the majority of cases provided the correct technic has been used However the interpretation of the roentgenograms is somewhat difficult

ELECTROSURGERY

Cautery Excision and Electrosurgery V Mannin ger Le Cancer 1935 12, 259-265

In surgery of neoplasms the author has used the Paquelin cautery electrocautery, and the high frequency coagulation currents rather than the knife It is possible to do a neater cleaner dissection while avoiding bleeding The lymphatic channels are sealed against transport of malignant cells Re implantations of these cells do not occur at the site of operation The resulting sterile fields allow the safe and more effective use of radium or x rays when these are indicated

The author believes that the absorption of autolysates by the body is reduced to a minimum when the lymphatics are sealed preventing intoxication

The high frequency currents should not be used in the vicinity of nerves, due to the injurious effect of over stimulation

The author describes the technic of operation He has used these methods in about 3 000 cases His mortality rate is very low and the survival rate is high (50 per cent in five years) In the future he intends to supplement surgery with radium more frequently, as he now has a sufficient supply at his disposal

S RICHARD BEATTY, M D

EPILEPSY

Value of Encephalogram in Differential Diagnosis between Hereditary and Symptomatic Forms of

Epilepsy F Laubenthal *Med Welt*, Feb 27 1937 11, 267-273 (Reprinted by permission from *British Med Jour*, May 8, 1937 p 75 of *Epitome of Current Medical Literature*)

The author has investigated 285 cases of epilepsy by means of encephalography. Fifty of these cases definitely belonged to the category of hereditary epilepsy, while in another 26 cases the diagnosis of hereditary epilepsy was probable. Marked encephalographic changes were found in a large number of cases of hereditary epilepsy. The most common changes were unilateral or bilateral enlargement of the lateral ventricles, enlargement of the third ventricle or else non filling of the ventricles, or enlargement unevenness, or mottling of the subarachnoid spaces. But the author never observed in hereditary epilepsy a hydrocephalic ventricular enlargement or a displacement of the ventricles or filling defects or excavations in the ventricular outline. In doubtful cases circumscribed changes in the subarachnoid filling pointed toward a local pathologic condition. There was no definite relation between the gravity and the duration of the epilepsy and the encephalographic changes. Pathologic changes in the cerebrospinal fluid were found mainly in cases showing ventricular enlargement. The encephalography proved perfectly harmless in 450 cases investigated.

THE EYE

Radiotherapy in Lesions about the Eye G E Richards *Am Jour Roentgenol and Rad Ther*, November, 1936 36, 588-602

The eye tolerates radium rather well much better than some other structures, and the dangers of corneal ulcer, secondary glaucoma, and cataract are remote especially when the cornea is protected by a gold or silver shield. The eye is completely shielded when a nearby area is treated.

Many conditions in or about the eye are benefited by radiological methods namely blepharitis, eczema of the lids, inverted lashes, papillomas, vernal catarrh, keratoses, nevi and angiomas of the lids, rodent ulcer and epithelioma and hyperplasia of the corneal epithelium. Cataract does not appear to be benefited although so claimed by earlier writers.

All the above diseases are reviewed in detail, technique described, cases cited and many illustrations shown.

S M ATKINS M D

THE FOOT

A Case of Spontaneous Peridiaphyseal New Bone Formation of the Second Metatarsal Charles Viallet and R Marchioni *Bull et Mém Soc Radiol Méd de France* February 1937 25, 169-172

Roentgenographs of the foot of a rather heavy woman 30 years of age, who had been suffering from pain for

several days, revealed a rounded buttress of new bone on the inferior medial side of the second metatarsal. Following a course of anti syphilitic treatment (the patient's serology was negative) the new bone formation was seen to involve the length of the shaft and some destruction of the shaft was apparent. After seven months except for disappearance of the area of destruction, the shaft showed little change. The authors believe this may be a case of 'pied forcé'.

S RICHARD BEATTY, M D

Avulsion of the Attachment of the Tendon Achilles. Case Report H DuBoucher C Viallet and R Marchioni *Bull et Mém Soc Radiol Méd de France* February, 1937, 25, 172-174

An oblique fracture of the superior posterior portion of the greater tuberosity of the calcaneus included the attachment of the tendon achilles. Treated by open operation and fixation with a pin through the fragment into the body of the calcaneus a perfect restoration of function was obtained.

S RICHARD BEATTY, M D

GENITO-URINARY TRACT (DIAGNOSIS)

Correlation of Clinical and Anatomical Studies of the Vesical Neck R E Van Duzen and W W Looney *Southern Med Jour* April 1937 30, 436-438

The authors have made an anatomical study of the vesical neck. From the anatomic and microscopic findings they conclude that the external longitudinal muscle fibers of the bladder detrusor muscle interlace with the circular fibers of the internal vesical orifice and perform a very important function in opening the internal vesical orifice at onset of the act of urination.

A discussion by Dr Hugh H Young and Dr Raymond Thompson accompanies the article.

DAVIS H PARDOLL M D

GRENZ RAYS

The Treatment of Lupus with Grenz Rays H L Banberg and P Kröker *München med Wehnschr* April 9 1937 84, 569-571

The authors prefer to handle their cases as outpatients. They describe their clinic organization. The action of Grenz rays like Finsen treatment depends on an inflammatory reaction with Grenz rays the reaction goes to vascular dilatation outpouring of cells and a serous exudation from neighboring vessels. This initiates a destruction of the diseased and neighboring normal tissues. Proper choice of treatment preserves the resistant connective tissue. The deeper vessels are not damaged because the rays are absorbed in the superficial structures. As a result of the inflammatory reaction the diseased top layers become necrotic. After

removal of the diseased crusts the uninjured vascular bed can initiate regeneration in the shape of scars, which are flat, not raised. The technic used, which does not strictly follow previously described works, consists in cleaning the lesion of crusts, and radiating 15 minutes with red light after which the Grenz treatment closely follows (9-10 kv, 10 ma 2.5-5 cm TSD half value, 0.0185-0.02 mm Al). Most lupus patients react to this with a strong inflammation which recedes the next day, or at latest the day after. After some weeks the crust drops off leaving at first a noticeable, but later an almost unnoticeable, scar. Keloids are not formed. By combined therapy two sources of inflammatory reaction combine their effect. Tuberculin may also be used to produce a specific inflammatory reaction, the treatment of the lesions with Ektabin before radiation produces an appreciable increase in reaction. The use of these measures must be accompanied by caution because of the possibility of generalized reactions. With the proper management only slight or no activation of (pulmonary) lesions previously quiescent is observed. With the combination method doses of from 1,000 to 1,500 r are given at 5 cm, occasionally as much as 2,000 r may be given. In a single course a lesion receives on an average not over from 15,000 to 20,000 r.

L. G. JACOBS, M. D.

Our Experience with Grenz ray Therapy in Lupus Vulgaris. A. Beller. *Strahlentherapie*, 1937, 58, 244.

During the last three years the author treated 39 cases of lupus vulgaris with Grenz rays. Technic: 8.5 kv 15 ma HVL_{0.017} mm. He divided his material arbitrarily in three groups according to the total dose given: 5,000 r from 6,000 to 10,000 r and from 11,000 to 18,000 r. There were seven patients in the first group two of whom were cured. In the second group were 19 patients one was cured one unimproved. In the third group were 13 patients none of whom showed any marked tendency to heal. In order to study the mechanism of the effect of radiation on the pathologic tissue biopsies were taken in a number of cases following irradiation. It appeared that even in clinically healed lesions typical changes or cell groups were found characteristic for lupus. This occurred even after very high doses. Caution is necessary in the use of roentgen rays because of the danger of carcinomatous or sarcomatous degeneration. Grenz ray therapy cannot be considered the method of choice for all cases with lupus vulgaris.

ERNST A. POHLE, M. D., Ph. D.

GYNECOLOGY

Treatment of Dysmenorrhea. L. J. Stacy and R. Shoemaker. *Am. Jour. Obst. and Gynec.*, January, 1937, 33, 67-71. (Reprinted by permission from *British Med. Jour.* April 10, 1937 p. 60 of *Epitome of Current Medical Literature*.)

The authors submit a study from the Mayo Foundation of 262 cases of dysmenorrhea, 132 were single women. Pregnancy had failed to cure 47 out of the 130 married women. Of these, six gained relief after treatment plus a second pregnancy, but six remained as before. Psychic and fatigue factors were noted in 82 cases. Results are tabulated according to type of treatment. (1) Drugs—antispasmodics, analgesics, sedatives, chiefly benzyl benzoate, barbiturates, belladonna, and calcium lactate, alone or in combination. After a course of such treatment 51 per cent showed benefit, some permanent. (2) Endocrines—alone, or combined with drugs at least for a time, primarily for cases showing menstrual irregularities. Of these, 60 per cent gained relief, relapses occurring unless treatment was maintained or repeated in an uncertain proportion. Ovarian extract, oestrin (progynon), placental hormone (emmenin), and sistomensin (luteal lipid of corpus luteum) are separately reported upon, the last being chosen when excessive loss as well as pain was present. Complete relief was obtained in 54 per cent with improvement in 55 per cent, but it is suggested that the endocrine preparations had very little effect. Irradiation of pituitary or ovaries was used in five cases with relief, but the method is for expert radiologists only. Radium in doses to induce temporary amenorrhea or full menopause applied in 16 selected cases, was successful in 69 per cent. For patients with disabling and otherwise incurable dysmenorrhea resection of the pre-sacral nerves is a possibility, relief being considerable and generally complete.

THE KIDNEYS

Pyelography in Renal Hydatids. R. C. Begg. *British Jour. Surg.* April, 1937, 24, 691-702.

The author discusses the pyelographic characteristics of the various types of renal hydatid cysts.

The main types are:

1. The pseudo-closed, in which the cyst communicates with the renal pelvis but the parasite is intact.
2. The open, in which the envelope of the parasite has ruptured.
3. The closed, in which the cyst does not communicate with the pelvis.
4. Secondary calyx cysts.

The effect of extrarenal cysts on the contour of the pelvis is illustrated.

Many illustrations of the pyelographic characteristics accompany the article.

DAVIS H. PARDOLL, M. D.

Technic of Nephropexy. Marion. *Rev. med. franç.* December 1936, 17, 781-790. (Reprinted by permission from *British Med. Jour.*, Feb. 13, 1937 p. 26 of *Epitome of Current Medical Literature*.)

The author describes nephropexy as an operation which has become increasingly popular as the technic has improved. For the procedure to be successful the kidney must be fixed securely in a high position.

Epilepsy F Laubenthal *Med Welt*, Feb 27 1937, 11, 267-272 (Reprinted by permission from *British Med Jour*, May 8, 1937, p 75 of *Epitome of Current Medical Literature*)

The author has investigated 285 cases of epilepsy by means of encephalography. Fifty of these cases definitely belonged to the category of hereditary epilepsy while in another 26 cases the diagnosis of hereditary epilepsy was probable. Marked encephalographic changes were found in a large number of cases of hereditary epilepsy. The most common changes were unilateral or bilateral enlargement of the lateral ventricles, enlargement of the third ventricle or else non filling of the ventricles, or enlargement, unevenness, or mottling of the subarachnoid spaces. But the author never observed in hereditary epilepsy a hydrocephalic ventricular enlargement, or a displacement of the ventricles, or filling defects or excavations in the ventricular outline. In doubtful cases circumscribed changes in the subarachnoid filling pointed toward a local pathologic condition. There was no definite relation between the gravity and the duration of the epilepsy and the encephalographic changes. Pathologic changes in the cerebro-spinal fluid were found mainly in cases showing ventricular enlargement. The encephalography proved perfectly harmless in 450 cases investigated.

THE EYE

Radiotherapy in Lesions about the Eye G E Richards *Am Jour Roentgenol and Rad Ther*, November, 1936, 36, 588-602

The eye tolerates radium rather well much better than some other structures and the dangers of corneal ulcer, secondary glaucoma and cataract are remote especially when the cornea is protected by a gold or silver shield. The eye is completely shielded when a nearby area is treated.

Many conditions in or about the eye are benefited by radiological methods, namely, blepharitis, eczema of the lids, inverted lashes, papillomas, vernal catarrh, keratoses, nevi and angiomas of the lids, rodent ulcer and epithelioma and hyperplasia of the corneal epithelium. Cataract does not appear to be benefited although so claimed by earlier writers.

All the above diseases are reviewed in detail technique described, cases cited, and many illustrations shown.
S M ATKINS M D

THE FOOT

A Case of Spontaneous Periaphyseal New Bone Formation of the Second Metatarsal Charles Viallet and R Marchioni *Bull et Mém Soc Radiol Méd de France*, February 1937 25, 169-172

Roentgenographs of the foot of a rather heavy woman 30 years of age who had been suffering from pain for

several days, revealed a rounded buttress of new bone on the inferior medial side of the second metatarsal. Following a course of anti syphilitic treatment (the patient's serology was negative), the new bone formation was seen to involve the length of the shaft, and some destruction of the shaft was apparent. After seven months except for disappearance of the area of destruction, the shaft showed little change. The authors believe this may be a case of 'pied forcé.'

S RICHARD BEATTY M D

Avulsion of the Attachment of the Tendon Achilles Case Report H DuBoucher, C Viallet, and R Marchioni *Bull et Mém Soc Radiol Méd de France* February, 1937 25, 172-174

An oblique fracture of the superior posterior portion of the greater tuberosity of the calcaneus included the attachment of the tendon achilles. Treated by open operation and fixation with a pin through the fragment into the body of the calcaneus a perfect restoration of function was obtained.

S RICHARD BEATTY M D

GENITO-URINARY TRACT (DIAGNOSIS)

Correlation of Clinical and Anatomical Studies of the Vesical Neck R E Van Duzen and W W Looney *Southern Med Jour* April 1937 30, 436-438

The authors have made an anatomical study of the vesical neck. From the anatomic and microscopic findings they conclude that the external longitudinal muscle fibers of the bladder detrusor muscle interlace with the circular fibers of the internal vesical orifice and perform a very important function in opening the internal vesical orifice at onset of the act of urination.

A discussion by Dr Hugh H Young and Dr Raymond Thompson accompanies the article.

DAVIS H PARNOLL M D

GRENZ RAYS

The Treatment of Lupus with Grenz Rays H L Banberg and P Kröker *München med Wchnschr* April 9 1937 34, 569-571

The authors prefer to handle their cases as out patients. They describe their clinic organization. The action of Grenz rays like Finnsén treatment depends on an inflammatory reaction with Grenz rays the reaction goes to vascular dilatation, outpouring of cells and a serous exudation from neighboring vessels. This initiates a destruction of the diseased and neighboring normal tissues. Proper choice of treatment preserves the resistant connective tissue. The deeper vessels are not damaged because the rays are absorbed in the superficial structures. As a result of the inflammatory reaction the diseased top layers become necrotic. After

the primary lesion had been operated on, the recurrence was treated by irradiation in six of these the glands had been removed at the time of the first operation eight responded well to the treatment and became free from symptoms Of two patients with primary carcinoma of the upper lip, one responded well to irradiation (treatment of recurrence)

The author concludes that recurrent and resistant carcinoma of the lip is usually due to insufficient treatment of the primary lesion Radiation therapy, however, has much to offer in the treatment of the recurrences Numerous case reports are found throughout the article, with good illustrations of lesions before and after treatment

ERNST A. POHLE, M.D., Ph.D.

THE LUNGS

The Interpretation of Roentgenograms of the Lungs
K. Heckmann München med Wehnschr, March 26, 1937, 84, 495-501

The author proposes a brief review of the field He first discusses the optical problems involved It is demonstrated how shadows are cast on the film and the fact that a certain size is required before a shadow is produced, is noted The summation of the effect of a series of small shadows, as in miliary tuberculosis is also mentioned, as well as the result of multiple shading from several penumbras To get best results then a small focus and great T.F.D. is necessary this is located by the inverse square law and the loading capacity of the tube Intensifying screens though they multiply the darkening of the film by about ten are limited by their fuzziness To obviate this ten superimposed films may be simultaneously exposed in cardboards, and a positive printed through all of them superimposed but this method is too expensive

Of the normal markings the tree like lung markings are caused mostly by the blood vessels Increased prominence in disease may occur in the vessels the bronchi or the lung substance or alveoli In vascular disease distinction is made between arterial and venous congestion, the former being marked by pulsating hilar tortuosity of the para hilar markings and normal radiability of the lungs while the latter is marked by large but not pulsating hilar large but not tortuous para hilar vessels and diminished radiability of the lungs Ky-mography may give supplementary information In mitral disease mixed forms occur the type predominating depending on the stage of compensation The bronchial tree plays but a small role in the picture of the normal and pathologic lung While the lung parenchyma takes part in practically all changes in the lung it is seldom primarily affected

Then he considers diseases producing shadows through replacement of air in the alveoli for example atelectasis The focal atelectasis of bronchitis and inflammatory exudates in the bronchi are considered such as pneumonia Localization is discussed and the diminution of volume of the involved lobe mentioned

The possibility of confusion with encapsulated interlobar effusion is discussed and interlobar effusion and thickening in general considered Oblique anterior projections are advocated for the study of such effusions, etc., in the major fissure Carcinoma is mentioned, and the rule that in atelectasis a small hilar carcinoma should be suspected is drawn The article is well illustrated

L. G. JACOBS, M.D.

Roentgen Therapy for Bronchiectasis Maurice Berek and William Harris Jour Am Med Assn, Feb 13, 1937, 108, 517-522

Roentgen therapy has been employed for a great and protean variety of pulmonary inflammatory diseases In small dosage it was employed by several different workers for 'unresolved pneumonia' and 'chronic pulmonary suppuration' with varying and, for the most part indifferent results Experience with small dosage in their radiotherapy department demonstrated to the authors a total failure of effect in bronchiectasis

The authors describe the deliberate and successful use of roentgen therapy in large dosage as the sole treatment of chronic secreting bronchiectasis This resulted in great symptomatic improvement in a considerable proportion of their cases

Follow-up examination over a period of two years in those cases in which there was improvement has shown no recurrence of symptoms with infections of the upper respiratory tract

CHARLES G. SUTHERLAND, M.B. (Tor.)

Differential Diagnosis between Primary Tumors and Tuberculosis of Lungs and Importance of Tuberculosis in Creating Precancerous Condition O. Feuchtinger Ztschr f Tuberk 1937 77, 81-107 (Reprinted by permission from British Med Jour, April 24 1937 p 65 of Epitome of Current Medical Literature)

The author discusses the etiology and differential diagnosis of carcinoma of the lung with special reference to ten personal cases He finds no proof for the belief that tuberculosis and carcinoma cannot co exist, or for the theory that carcinoma arises necessarily from a precancerous condition occasioned by tuberculosis Only three of his cases had tuberculosis and in none of them was it associated in any way with the carcinoma He suggests that when tuberculosis and tumor co exist this might occur because of a simultaneous appearance of both (very rarely) because an old tuberculous lesion develops into a cancerous one (rarely), or more commonly because a latent or active tuberculosis turns to carcinoma or a carcinoma activates tuberculosis Tobacco appeared to have some significance, for seven of the author's patients were heavy smokers The ratio of men to women was 8 to 2, confirming the findings of other authors Heredity appeared to be significant for of four patients with a family history of cancer three

Failures in the past have been due to faulty technic. The operation is recommended for those patients with pain, dilatation of the pelvis of the kidney and chronic infection or hemorrhage for which medical treatment has been unsuccessful. Pyelography should be carried out before operation. The technic of the procedure which is based on that of Surraco, is fully described and illustrated. It consists of the exteriorization of the displaced kidney, examination of the junction of the pelvis and the ureter, fixation of the kidney by means of linen sutures passed round the twelfth rib, formation of a sling composed of renal capsule to support the kidney, and drainage and closure of the wound. If displacement is bilateral intervention may be carried out on both sides during the same operation. The patient should remain in bed for three weeks so that sound healing may take place.

Renal Tumor in a Displaced Kidney M. Bernasconi. *Bull. et Mém. Soc. Radiol. Méd. de France*, February, 1937, 25, 155.

An enormous solid tumor extending from the left to the right iliac fossa and filling the latter was shown by pyelography to originate in the left kidney which had been displaced to the right.

S. RICHARD BEATTY, M.D.

Calcified Hydatid Cyst of the Kidney Bernard P. Goinard and Le Génissel. *Bull. et Mém. Soc. Radiol. Méd. de France*, February, 1937, 25, 145-147.

A case of calcified hydatid cyst of the lower pole of the kidney is presented, diagnosed by plain films and confirmed by pyelography and operation.

S. RICHARD BEATTY, M.D.

Importance of Respiration Pyelography in Diagnosis of Paraneuritic Abscesses F. Breuer. *Zentralbl. f. Chir.* March 20, 1937, 64, 683-686. (Reprinted by permission from *British Med. Jour.* May 8, 1937, p. 75 of *Epitome of Current Medical Literature*.)

The author asks for trial of Hilgenfeldt's recently described device for the radiological detection of perineuritic abscess after transvesical (or other) filling of the renal pelvis with an opaque substance. Two successive radiographs are superimposed, one being taken in full expiration, the other in full inspiration. The healthy side shows the usual sinking of the kidney on inspiration; in a case in which there is a perineuritic abscess the image does not descend. In one of Breuer's cases this procedure allowed of a definite early diagnosis in a fat subject. Hilgenfeldt's method is also said to be of use in defining the connection or lack of connection of foreign bodies with the kidney.

THE KNEE JOINT

Congenital and Recidivating Luxation of Patella Dr. Hustinx. *Le Scalpel* Oct. 31, 1936, 89, 2304-2309.

(Reprinted by permission from *British Med. Jour.* Dec. 19, 1936, p. 102 of *Epitome of Current Medical Literature*.)

The author points out that the most common type of dislocation of the patella is external. Dislocation upward, downward or internally is rarely seen without some underlying pathologic condition. There are two different forms, that in which the dislocation is complete when the patella has lost all contact with the anterior surface of the external condyle and the incomplete type, when the patella leaves the anterior surface of the condyle only in full flexion. There are many intermediate stages and recurrence is often seen, due to repeated trauma. Congenital dislocation is usually associated with some pathologic condition of the knee, such as genu valgum, hypertrophy of the external condyle in cases in which the patella ligament is displaced laterally or when there is relaxation of the muscles and ligaments of the knee.

Discovery of the condition is made at different stages of development. Sometimes a child refuses to walk, has pain, or falls easily; in other cases the first symptoms develop only after some trauma. Treatment depends on the associated condition of the knee. In some instances in which the dislocation has not been noticed and the structure of the joint has accommodated itself so that little discomfort is felt, surgical treatment would only aggravate the condition. In cases of recurrence in which treatment is necessary the osteoplastic method is recommended. This consists of three procedures: detachment of the tendon of the patella from the head of the tibia, sliding this toward the inner side and freeing the outer border of the patella and the patellar ligament on the same side to allow of the displacement to the inner side. The loss of substance in the vastus externus is then replaced by a fascial graft. The third procedure consists in the plication of the ligaments on the inner side and the vastus internus according to the method of Ugo Camera. A case is reported of congenital dislocation of the patella of both knees in a boy of 11. Operative treatment was carried out on both sides and resulted in complete cure in the case of the right knee and considerable improvement in the left.

THE LIPS

Resistant Carcinomas of the Lip and Their Cure A. Hintze. *Strahlentherapie* 1937, 59, 1.

Carcinoma of the lip may be cured by various methods of treatment. Recurrences usually start from a temporarily healed lesion although additional new primary foci are possible. During 1912-1932 the author observed 29 cases of resistant carcinoma of the lip, 24 had been treated by surgery and five by radiation. In 25 cases the cancer was in the lower lip and in four cases in the upper lip. Six patients who had the first lesion removed surgically and the recurrence again removed surgically were all cured for periods of 15, 17, 19, 19, 25 and 37 years respectively. In 15 patients in whom

the primary lesion had been operated on, the recurrence was treated by irradiation in six of these the glands had been removed at the time of the first operation eight responded well to the treatment and became free from symptoms Of two patients with primary carcinoma of the upper lip, one responded well to irradiation (treatment of recurrence)

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ERNST A. POHLE, M D , Ph D

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had cancer of the lung. Etiologic factors mentioned by other authors—for example, dust, profession, habitat, avitaminosis, war conditions, etc.—were not found in Feuchtinger's cases. He admits that the differential diagnosis is difficult, but maintains that diagnosis is possible in 50 per cent in the first and 80 per cent in the later stages of the disease.

X ray examination, bronchoscopy, and exploratory thoracotomy yield the best results in differential diagnosis. In the history the presence of possible etiologic factors especially occupational ones may help. Physical examination rarely allows of differentiation between cancer and tuberculosis (all ten cases had been diagnosed as tuberculous). The presence or absence of tubercle bacilli in the sputum does not exclude the occurrence of cancer, but bloody sputum in the absence of tubercle bacilli in elderly persons is strong presumptive evidence of cancer. Tumor cells are only rarely found in the sputum. Hematologic and serologic tests are of value only in conjunction with other evidence. Increasing pain and dyspnea in the thorax after tapping of a pleural exudate is in the author's opinion, very suggestive of the existence of carcinoma.

Diagnosis and Treatment of Primary Cancer of the Lung. A. C. Christie. *British Jour Radiol* March 1937, 10, 141-158. (Reprinted by permission from *British Med Jour*, May 8, 1937, p. 75 of *Epitome of Current Medical Literature*.)

The author first discusses the diagnosis and the differential diagnosis of the primary carcinoma of the lung from the general clinical and special radiological

points of view. Recent statistics have proved that carcinoma of the lung is very frequent, more frequent, for example than carcinoma of the esophagus. Surgical treatment, whether lobectomy or pneumonectomy, has had some successes. There appears to be no room for pre-operative irradiation treatment but post-operative irradiation is useful in certain cases. When irradiation treatment alone is applied, high filtration—at least 2 mm. of copper—should be used, and treatments given every day for from sixty to seventy days through small fields until a total dose of 12,000 r units is reached. These large doses are certain to result in an x ray pleuropneumonitis, but this should not deter the radiologist from giving an adequate dose.

Air filled Cyst of the Lung. R. O. Tanguy. *Bull et Mém Soc Radiol Méd de France*, February, 1937, 25, 163-165.

Discussing briefly the clinical and radiologic findings, the author presents a case of solitary cyst of the lung replacing the left upper lobe above the level of the fifth rib anteriorly.

S. RICHARD BEATTY, M.D.

A Case of Lung Stones. Thuodet and Bertrand. *Guy Bull et Mém Soc Radiol Méd de France*, February, 1937, 25, 165-166.

Roentgenographs of a case with multiple calcifications in the lung parenchyma before and after the patient expectorated one or more stones show diminution in the number of calcified nodules.

S. RICHARD BEATTY, M.D.

RADIOLOGY

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CLASSIFICATION OF MAMMARY CARCINOMAS TO INDICATE PREFERABLE THERAPEUTIC PROCEDURES¹

By U V PORTMANN, M D, Cleveland Clinic *Cleveland, Ohio*

It is often difficult, if not impossible, to evaluate the different therapeutic procedures which have been employed in the treatment of mammary carcinomas because but few statistical reports are based upon series of cases classified either from clinical or pathologic aspects. This point has been illustrated on several occasions by a table which I compiled from the reports of many surgeons about the results which they have obtained by operations during the past 20 years (Table I). The five-year survival rates vary

from 15 to over 50 per cent, and the mean average is about 28 per cent. Such a wide variation in the results obtained by indisputably competent surgeons from well accredited hospitals and clinics may indicate that different surgeons may have selected for operation patients with different types of carcinomas and that those who report comparatively low survival rates operated upon patients with more advanced disease than did these reporting the higher rates. This explanation of the variations is probably correct because each surgeon had the same anatomical limitations, and the types of surgical procedures used probably would not generally vary a great deal.

It is just as difficult to draw conclusions about the effectiveness of irradiation in the treatment of mammary carcinoma when the cases are not classified. In addition, many reports which compare the results secured in irradiated and non-irradiated cases are made by individuals who are not well informed about radiological procedures, and usually they have not taken into consideration when, why, or how irradiation was administered.

When the results of treatment are reported, especially from a prognostic standpoint, the importance of classifying malignant diseases on some generally acceptable basis is illustrated by the advantages which have come from grouping cases of carcinoma of the uterine cervix. When good results in the treatment of carcinomas of the cervix were first reported by radiolo-

TABLE I—SURGICAL CURABILITY OF CANCER OF THE BREAST FIVE-YEAR SURVIVALS

Author	Per cent	Author	Per cent
Lee and Cornell	15 0	Faure	28 2
Rahm	15 9	Hoffmann	28 5
Lindner	17 0	Halsted	28 9
Smith	17 0	Buchanan	29 0
Gibson	18 0	Black	30 0
Hartmann and Bergeret	19 0	Deelman	30 6
Grassmayer	20 3	Braine and Massie	31 0
Tichy	20 9	Morton	31 0
Schwarzkopf	21 0	Lindenberg	31 4
Neber	21 0	Steinthal	33 3
Forgue	22 0	Moschcowitz <i>et al</i>	34 0
Brattström	23 0	Schoute and Orbaan	35 9
Broeström	23 0	White	36 0
Bunts	24 1	Iselin	36 4
Sadler	24 3	Smith and Bartlett	37 0
Dahl	24 5	Crile	37 4
Jennings	25 0	Peck and White	39 1
Harrington	25 8	Judd	39 8
Greenough	27 0	Mills	39 8
Perthes	27 7	Primrose	44 4
Gernade	28 0	Wintz	48 5
Lehmann	28 0	Watson Cheyne	52 1

Mean average = 28 0 per cent

¹ Presented before the Radiological Society of North America at the Twenty second Annual Meeting, Cincinnati, Nov 30-Dec 4 1936

gists there was considerable skepticism among surgeons and even animosity toward radiological procedures. This led to the classification of cases in order that operative results might be compared on an equitable basis with results obtained by radiological methods. A number of years ago the American College of Surgeons adopted a classification which has proved quite satisfactory and has been generally accepted in this country, because those who used it knew what each different group represented, and there was mutual understanding. Furthermore, it was applicable for prognostication and for the equitable comparison of different methods of treatment. It will be recalled that this classification for carcinoma of the cervix is based upon the stage of the disease or its extent at the time of treatment.

Peculiarly enough, no such plan has yet been accepted for the classification of cases of mammary carcinoma. I believe that it would be advantageous to adopt some plan for grouping cases of mammary carcinoma so that, in the future, better information will be available upon which to base prognosis and to indicate what therapeutic procedures have been found to be preferable as well as to establish greater uniformity in publications about comparative results. Such a classification might be based upon a correlation of the interrelated clinical and pathologic aspects of the disease.

I would like to discuss some of the methods which already have been suggested for classifying mammary carcinomas.

Pathologists have attempted to classify carcinomas of the breast according to histogenesis and morphology. As far as histogenesis is concerned, it must be conceded that all carcinomas originating in the mammary gland itself must develop in or from the epithelial cellular elements of the lacteal duct system. There may be other carcinomas which affect the mammary gland secondarily but which do not originate in gland structures. However, some carcinomas which originate in one part of the mammary duct system vary in

morphology from others of similar origin, and many carcinomas which apparently are of a certain anatomical derivation may present quite different histologic characteristics in different areas of the tumor. Therefore, since classifications of mammary carcinomas on the basis of histogenesis alone are fallible, pathologists are forced to distinguish them by applying descriptive adjectives to characterize differences in the histologic appearances. This often results in confusion when the clinician tries to interpret physical manifestations or the clinical course in accordance with these various adjectives which describe morphology but give no intimation of the extent of the disease.

The eminent authority in pathology, Dr James Ewing (1), has recently suggested the following classification for mammary carcinomas:

- 1 Adenocarcinoma arising in cysts,
- 2 Mucous or gelatinous carcinoma,
- 3 Duct carcinoma
 - (a) Localized duct carcinoma co medo-carcinoma,
 - (b) Diffuse duct carcinoma,
- 4 Paget's disease,
- 5 Carcinoma arising on chronic mastitis,
- 6 Sweat-gland cancer,
- 7 Inflammatory carcinoma,
- 8 Histologic designations
 - (a) Medullary carcinoma,
 - (b) Scirrhus carcinoma,
 - (c) Fibrocarcinoma,
 - (d) Carcinoma *en cuirasse*,
 - (e) Carcinoma simplex

In this plan an attempt is made to establish a classification of mammary carcinomas according to histogenesis, but this proves to be too difficult, and therefore, terms employed to specify histogenesis are intermingled with clinical terminology and adjectives describing morphology. For example, the words "mucous" and "gelatinous" are descriptive adjectives, yet "mucous or gelatinous carcinoma" is given individual identity in this classification, although either adenocarcinoma, arising in cysts, or duct carcinoma, otherwise quite different morphologically and histogenically, may produce intracellular mucus or gelatin.

Paget's disease is classed as a carcinoma, yet this condition of the nipple which Paget first described apparently may be benign at one time and malignant at another, hence, a clinical term is applied as if it were a pathologic entity. The same applies to carcinoma *en cuirasse*. This is a clinical description meaning that a malignant process has extended around the trunk, which is probably not a characteristic of only one morphologic type. "Sweat-gland cancer" may or may not be primarily a mammary gland carcinoma yet it may affect the breast and there often is uncertainty as to its histogenesis. There also may be some dispute about "inflammatory carcinoma" as an entity because different morphological types of mammary carcinomas apparently may present clinical manifestations which conform to the classical clinical definition of inflammation, namely, pain, heat, redness, and swelling.

Such a classification may be eminently satisfactory for pathologists, but I believe that classifications which are based on our present knowledge of histogenesis, histologic characteristics, or the cytology of neoplasms cannot be applied clinically with satisfaction and consistency to establish prognosis or indicate therapeutic procedures for different types of growth. The principal objections are that tumors of apparently the same origin may present one or several different types of morphology, and there is no way to determine with accuracy the anatomical extent of the disease by the histologic characteristics of a neoplasm.

In addition to the commendable efforts of pathologists to classify mammary carcinomas according to histogenesis or morphology, some have been interested in grouping or grading them according to variation in some of their histologic characteristics which may indicate differences in degrees of differentiation or anaplasia and, therefore, differences in degree of malignancy. This idea was suggested as early as 1893 by David P. von Hausemann (2) who taught that the degree of anaplasia of neoplastic cells was an index of the degree of malignancy and was of prognostic

significance. Other suggestions about histologic characteristics which might indicate the degree of anaplasia have been described and advocated as a basis for classifications or grading of neoplasms. C. D. Haagensen (3) recently collected 15 such suggestions from the medical literature and applied each to a remarkably well organized and controlled series of cases of mammary carcinomas. He found that only six histologic characteristics had prognostic significance, and he tabulated them in the following manner:

- 1 Papillary character origin in a cyst formed in a duct,
- 2 Comedo character growth mainly in ducts, often with central necrosis,
- 3 Adenoid arrangement of cells
 - (a) Marked,
 - (b) Slight,
 - (c) Absent,
- 4 Variations in size and shape of nuclei
 - (a) Slight,
 - (b) Moderate,
 - (c) Marked,
- 5 Number of mitoses
 - (a) Few,
 - (b) Moderate,
 - (c) Numerous,
- 6 Gelatinous degeneration

If we attempt to classify mammary carcinomas on the basis of differences in morphology or histologic characteristics, it must be done after removal of the tissues and not on the basis of any clinical information, and again we encounter descriptive adjectives and also uncertainty among different individuals as to the degrees of anaplasia in any one neoplasm and even divergent opinions about different areas in a single tumor. As a result of his studies, Haagensen concluded that histologic grading "is only an approximation, and a rough one at that" and "should not be regarded as in any sense competing with clinical data bearing on prognosis to which it is, of course, subordinate in importance." In discussing this presentation, Dr. Ewing evidently concurred in this opinion. He said "When it comes to predicting what will happen to a patient, certainly no pathologist and no clinician will ever say that histological grad-

gists there was considerable skepticism among surgeons and even animosity toward radiological procedures. This led to the classification of cases in order that operative results might be compared on an equitable basis with results obtained by radiological methods. A number of years ago the American College of Surgeons adopted a classification which has proved quite satisfactory and has been generally accepted in this country, because those who used it knew what each different group represented, and there was mutual understanding. Furthermore, it was applicable for prognostication and for the equitable comparison of different methods of treatment. It will be recalled that this classification for carcinoma of the cervix is based upon the stage of the disease or its extent at the time of treatment.

Peculiarly enough, no such plan has yet been accepted for the classification of cases of mammary carcinoma. I believe that it would be advantageous to adopt some plan for grouping cases of mammary carcinoma so that, in the future, better information will be available upon which to base prognosis and to indicate what therapeutic procedures have been found to be preferable as well as to establish greater uniformity in publications about comparative results. Such a classification might be based upon a correlation of the interrelated clinical and pathologic aspects of the disease.

I would like to discuss some of the methods which already have been suggested for classifying mammary carcinomas.

Pathologists have attempted to classify carcinomas of the breast according to histogenesis and morphology. As far as histogenesis is concerned, it must be conceded that all carcinomas originating in the mammary gland itself must develop in or from the epithelial cellular elements of the lacteal duct system. There may be other carcinomas which affect the mammary gland secondarily but which do not originate in gland structures. However, some carcinomas which originate in one part of the mammary duct system vary in

morphology from others of similar origin, and many carcinomas which apparently are of a certain anatomical derivation may present quite different histologic characteristics in different areas of the tumor. Therefore, since classifications of mammary carcinomas on the basis of histogenesis alone are fallible, pathologists are forced to distinguish them by applying descriptive adjectives to characterize differences in the histologic appearances. This often results in confusion when the clinician tries to interpret physical manifestations or the clinical course in accordance with these various adjectives which describe morphology but give no intimation of the extent of the disease.

The eminent authority in pathology, Dr James Ewing (1), has recently suggested the following classification for mammary carcinomas:

- 1 Adenocarcinoma arising in cysts,
- 2 Mucous or gelatinous carcinoma,
- 3 Duct carcinoma
 - (a) Localized duct carcinoma comedo-carcinoma,
 - (b) Diffuse duct carcinoma,
- 4 Paget's disease,
- 5 Carcinoma arising on chronic mastitis,
- 6 Sweat-gland cancer,
- 7 Inflammatory carcinoma,
- 8 Histologic designations
 - (a) Medullary carcinoma,
 - (b) Scirrhus carcinoma,
 - (c) Fibrocarcinoma,
 - (d) Carcinoma *en cuirasse*,
 - (e) Carcinoma simplex.

In this plan an attempt is made to establish a classification of mammary carcinomas according to histogenesis, but this proves to be too difficult, and therefore, terms employed to specify histogenesis are intermingled with clinical terminology and adjectives describing morphology. For example, the words "mucous" and "gelatinous" are descriptive adjectives, yet "mucous or gelatinous carcinoma" is given individual identity in this classification, although either adenocarcinoma, arising in cysts, or duct carcinoma, otherwise quite different morphologically and histogenically, may produce intracellular mucus or gelatin

entirely different category from those in which there is any degree of axillary involvement, and that this can be ascertained only after careful search and microscopic examination

Another interesting and ingenious method of classifying mammary carcinomas, especially for prognostic purposes, was suggested by B J Lee and J G Stubenbord (5)

	Weighting Factor	Gradation Factor	
Age	A = 2	Over 55	= 1
		A _G 41-55	= 2
		40 or under	= 5
Lactation	L = 3	Absent	= 0
		L _G Present	= 3
		Slow	= 1
Rate of Growth	R = 4	R _G Moderate	= 2
		Rapid	= 4
		Small, 3 cm	= 1
Extent of Disease	E = 5	E _G or less	
		Large	= 2
		Nodes present	= 4

$$C I M = 2A_G + 3L_G + 4R_G + 5E_G$$

Grade A—C M I = 11 to 25—relatively benign

Grade B—C M I = 26 to 39—moderately malignant

Grade C—C M I = 40 to 55—highly malignant

This scheme is established on certain clinical findings to which numerical evaluations are assigned, according to what experience has proved may be their relative significance in prognosis. A summation of these values, in any case, places it in one of three grades or groups, each of which has a different total valuation

According to this plan of classification, it is apparently assumed that a definite diagnosis of mammary carcinoma is already established, but to distinguish between benign and malignant tumors in the breast is not always easy

We also find in this plan several variables and some factors which depend upon the personal history rather than definite physical evidences of the disease, and therefore the method is subject to criticism

The first weighting factor employed is

based upon the age of the patient, and the corresponding gradation values are apparently established upon the theory that the younger the patient the more malignant a carcinoma will prove to be, because the ages under 40 are given a relatively very high value compared with the values given to ages of 55 or over. It must be conceded that mammary carcinomas usually appear to grow more rapidly in younger rather than in older women. However, given two patients, one under 40 and one over 55, each with a localized carcinoma of the same size and without metastases, the prognosis for each will be exactly the same if each tumor can be removed completely, that is, both patients probably will survive. In other words, it is the extent of the disease at the time of treatment that is of prime importance rather than the age of the individual, other factors being the same

Experience seems to indicate that the second weighting factor, lactation, has some bearing upon the rate of dissemination of mammary carcinomas, yet if malignant neoplasms can be removed completely from a lactating breast before they have extended outside the gland, the prognosis is just as good as in a quiescent organ. But, unfortunately, the neoplastic processes that develop in the breast at the time of pregnancy are usually considered to be associated with certain phases of the physiologic activity of the gland and the neoplastic process may be overlooked by both patient and physician until the growth has had time to be widely disseminated and the patient is in a hopelessly incurable condition. Lactation may be of significance when present but is of very little significance when absent. According to our experience, carcinoma has occurred in lactating breasts in much less than 2 per cent of all cases

The third weighting factor of rate of growth depends to a great extent upon the history, or time at which the patient thinks she discovered the tumor, and her own estimation of the rate at which it enlarged. This is seldom conclusive or even satisfactory evidence

The fourth weighting factor concerns

ing will give us the information that can be obtained from the clinical index."

It must be apparent that one of the chief difficulties which will be encountered in classifying carcinomas according to their degrees of differentiation from a prognostic standpoint, will be due to the fact that some patients with histologically highly malignant anaplastic but localized neoplasms which are completely removed, survive while others with much less malignant and differentiated growths succumb to the disease. This can be explained only on the basis of differences in the extent of the disease in each instance. Therefore, unfortunately, we cannot depend upon these microscopic evidences as a basis for satisfactorily classifying cases of mammary carcinoma in order to indicate the prognostic or the preferable therapeutic procedures, although when the degree of anaplasia in a neoplasm can be ascertained, the rate at which dissemination may take place may be indicated.

These considerations lead us to contemplate the possibility of classifying cases of mammary carcinoma solely on the basis of information obtained about the extent of the disease by clinical examinations.

Several methods for classifying cases of mammary carcinoma on purely clinical findings have been published. Perhaps one of the first which was favorably received was that of C F Steinthal (4) who grouped a series of cases in the following manner:

Group I Those having a tumor, apparently growing very slowly, and measuring only a few centimeters in diameter, entirely confined to the mammary gland, the skin is not yet attached and the axillary nodes are few in number and are first discerned only at operation.

Group II Those with definitely growing tumors which, after remaining stationary for some time, begin to increase in size, the skin becomes adherent, and nodes in the axilla are definitely demonstrable.

Group III Those in which a large part of the mammary gland has become involved, the tumor has invaded the skin and

underlying structures, and frequently the supraclavicular nodes are also involved.

A few criticisms of the method may be offered. In Group I are tumors "apparently growing very slowly." Unfortunately, the rate of growth, especially of small tumors in the breast, often is very difficult to determine with satisfactory accuracy because conclusions must be based upon the notoriously inaccurate observations and ignorance of most women about their anatomy. In many cases clinicians have reason to believe that a breast tumor has existed much longer than can be determined from the personal history. Secondly, the size of a tumor is no indication of the extent of the disease because not infrequently distant metastases will be found from tumors that are "only a few centimeters in diameter," and large tumors may not metastasize until relatively late. Thirdly, some cases are included in this group in which "the axillary nodes are few in number and are first discerned only at operation." The presence of axillary metastases contradicts the previous postulate that the disease should be "entirely confined to the mammary gland." Experience indicates, and I hope to demonstrate, that when a mammary carcinoma has extended to the axillary nodes in any degree, the condition is less favorable than if the growth is still localized entirely within the breast.

In addition, in Steinthal's Group II we find again that difficulty of deciding about the rate of growth of a tumor and of ascertaining if "nodes in the axilla are definitely demonstrable." On the basis of our studies and the reports of others, I believe that axillary metastases will be found in from 70 to 75 per cent of all cases. In our series, their presence was definitely demonstrable clinically in only about half of those patients who had them. Also, there may be uncertainty about axillary involvement in many cases even after gross examination of tissues removed at operation and not infrequently microscopic examination gives the only reliable confirmation. Therefore, I believe that when there are no axillary metastases, cases should be placed in an

It is obvious that usually it would be difficult—if not impossible—to distinguish our Group I from our Group II cases by physical evidences alone. But on the other hand, cases that would be classed in either of these two groups can usually be distinguished from Group III cases by clinical manifestations which are not so obscure. These will be discussed in greater detail later.

In order to illustrate the applicability of this classification to a large series of cases of mammary carcinoma, I would like to discuss our experiences to show (1) the relative proportion of cases in each group,

clude that approximately 30 per cent of women with mammary carcinoma have no axillary metastases (Group I, 29.4 per cent), that one-quarter (Group II, 25.9 per cent) have axillary metastases with still localized movable tumors, that almost one-half have advanced carcinomas (Group III, 44.7 per cent), and that about 70 per cent of all patients have axillary metastases or even more extensive disease by the time they appear for operation (Group II plus Group III). No doubt the same relative proportions would be found in any large series of cases, as indicated by the reports in the literature that from 70 to 75 per cent of all

TABLE II—CARCINOMA OF THE FEMALE BREAST¹ ALL CASES
Primary operations by Dr. George Crile 1895-1931 (Courtesy of Dr. Allen Graham)

	Total Cases		Operation Only Non-irradiated Series		Operation Plus Roentgen Therapy Irradiated Series	
	No.	Per cent	No.	Per cent	No.	Per cent
Number of cases	405		170	42.0	235	58.0
Unclassifiable	32	8.0	27	16.0	5	2.0
Classified	373	92.0	143	84.0	230	99.8
Group I	110	29.4	52	36.3	58	25.2
Group II	96	25.9	26	18.2	70	30.4
Group III	167	41.7	65	45.5	102	44.4
Group II plus Group III (with axillary metastases)	263	70.6	91	63.7	172	74.8

¹ Exclusive of Paget's disease, sweat gland cancer, papillary carcinoma, sarcoma.

TABLE III—CLASSIFIED TRACED CASES FOR COMPARISON OF RESULTS

	Total Cases	Group I		Group II		Group III	
		No.	Per cent	No.	Per cent	No.	Per cent
Irradiated series post-operative prophylactic roentgen therapy (1922-1931)	99	21	21.2	37	37.3	41	41.5
Non irradiated series operation only	85	21	24.7	23	26.0	41	48.3
Totals	184	42	22.8	60	32.6	82	44.6

and (2) the difference in the prognosis for each group on the basis of the therapeutic procedures employed.

I will use 405 cases of mammary carcinoma which were primarily operated upon by Dr. George Crile between 1895 and 1930, inclusive, and classified by Dr. Graham (Table II). The records were complete enough so that 92 per cent could be classified. Of these classifiable cases, 29.4 per cent were placed in Group I, 25.9 per cent in Group II, and 44.7 per cent in Group III.

Therefore, if we may use this experience as a basis for generalization, we may con-

clude that approximately 30 per cent of women with mammary carcinoma have been found to have axillary metastases.

Obviously, each of our groups has a different prognosis. This will be illustrated by two series of Dr. Crile's cases that I have studied in order to make a comparison between one series in which operation was the only treatment and another to which I gave roentgen therapy post-operatively. I will call the first series the non-irradiated group and the other the irradiated group. It is to be noted that his comparison will be based on two series of traced cases of mammary carcinoma in which only one surgeon operated upon each patient, and

the extent of the disease and this is established, first, upon a tumor size of three centimeters less or more, and second, upon the presence of axillary nodes. I believe that it seldom is possible to estimate the dimensions of a tumor in the breast with accuracy by clinical examination in comparison to its actual size and certainly not within two centimeters. Also, very large carcinomas may occur in the breast, especially of the type which originate in papillary cysts, without any evidence whatsoever that the disease has extended outside the mammary gland, and complete removal will apparently cure the patient. On the other hand, carcinomas less than three centimeters in diameter may have metastasized before they are discovered. The question of the presence or absence of involvement of the axillary nodes has previously been discussed, but I may repeat that the presence of axillary metastases can be predetermined in only about one-half the patients who have them.

I am fully aware that any method for classifying mammary carcinomas is subject to criticism, yet I am bold enough to suggest still another which is based upon both clinical and pathological evidences of the extent of the disease. We have found this method to be practical for the interpretation of the extent of the disease as determined by physical examination, it indicates the prognosis with satisfactory consistency, and it is especially useful in obtaining uniformity in a statistical review of cases. I would like to discuss this classification also as a means of indicating what therapeutic procedures I think are preferable for different groups of patients according to our modern concepts of the treatment of malignant diseases, by making deductions from our own series of cases.

This classification was developed when Dr. Allen Graham, pathologist at the Cleveland Clinic, made a very thorough study of all cases of mammary carcinoma operated upon by the members of our surgical staff. He arrived at a very definite conclusion, namely, that these cases could be divided into four groups according to

certain manifestations of the extent of the disease and the prognosis in individual cases could be based on these findings (6). I employed a similar classification in studying and comparing the results obtained in a series of these cases in which operation was the only treatment and in another series in which post-operative roentgen radiation was given (7). However, I divided the cases into only three groups, the difference being that Dr. Graham made a separate group of those with histologic evidence of malignancy but without gross tumor in the breast and no axillary metastases, while I, for the sake of simplicity, included in one group such cases as well as those in which tumor was also present in the breast without axillary metastases. The classification is arranged as follows:

Group I

- (a) Tumor definitely localized in the breast and movable,
- (b) Skin not involved,
- (c) Metastases not present in axillary lymph glands

Group II

- (a) Tumor localized in the breast and movable,
- (b) Skin not affected (or only very slightly edematous or ulcerated),
- (c) Metastases present in axillary lymph glands but few involved

Group III

- (a) Tumor diffusely involving the breast,
- (b) Skin involved (edematous, ulcerated), multiple nodules,
- (c) Metastases to numerous axillary lymph glands or to other tissue (supraclavicular nodes, lungs, bones, etc.)

This plan includes both clinical and pathological findings about the anatomical extent of the disease. We have found that it is necessary to take these two aspects into consideration because physical examination will reveal the presence of axillary metastases in only about one-half the cases in which they are present, and therefore a pathologist's examination is essential because the prognosis and indications for therapeutic procedures must depend upon this complete information about the extent of the disease.

TABLE IV — KNOWN FIVE-YEAR RESULTS IN 85 NON-IRRADIATED CASES AND 85 SELECTED IRRADIATED CASES

(All Groups Equal	Results by Percentages)			
	Group I	Group II	Group III	All Cases
Number of cases				
Non irradi	21	23	41	85
Irrad	21	23	41	85
Lost or died of cause other than cancer under 5 years				
Non irradi	23 7	8 7	12 2	14 1
Irrad	14 3	8 7	9 7	10 6
Remaining for estimate of 5-year known results				
Non-irradi	78 3	91 3	87 8	85 9
Irrad	85 7	91 3	90 3	89 4
Known dead of cancer within 5 years				
Non irradi	0	47 5	97 3	61 6
Irrad	5 5	23 8	91 9	52 6
Known survived or dead with cancer after 5 or more years				
Non irradi	0	4 7	2 7	2 7
Irrad	0	4 8	8 1	5 2
Known survived without cancer 5 or more years				
Non irradi	100 0	47 6	0	35 6
Irrad	94 5	71 4	0	42 2
Known survived with or without cancer 5 or more years				
Non irradi	100 0	52 4	2 7	38 3
Irrad	94 5	76 2	8 1	47 4

nodes will survive for five or more years after radical operation alone, and that roentgen irradiation cannot benefit them because all the disease has already been removed

The results obtained in our Group II irradiated series may be used to illustrate the prognosis from the treatment of patients with localized movable tumors in the breast but with only a few axillary lymph nodes showing metastases. We found in the series having operation alone that almost half (47.6 per cent) were free from demonstrable evidence of cancer and a little more than half (52.4 per cent) still survived five or more years with or without evidence of their disease. When these results are compared with our irradiated Group II cases in which the disease was present to the same extent we find 71.4 per cent are free from demonstrable evidences of cancer and about three-quarters of them (76.2 per cent) are still surviving

five or more years with or without evidences of their disease

It seems justifiable to conclude from this study of our Group II cases that about half the patients with carcinomas localized in the breast but with even a moderate degree of axillary metastases will survive five or more years if operation is the only treatment but, if roentgen irradiation is given after operation, more of them will survive for the same period of time

This observation about Group II cases is in distinct contrast to the results obtained in the Group I series in which axillary metastases were absent and the prognosis was almost certain cure by operation alone. Apparently the explanation of the benefits from irradiation in the Group II cases is not that more of these patients are definitely cured, but that their lives are prolonged by the treatment. This was proven in a year-to-year study of the survival rates in each of our series. It was found that the percentage of non-irradiated patients surviving in each yearly period after operation alone was about the same as the percentage of irradiated patients surviving in the next succeeding year. This indicated that the treatment extended the average life expectancy of the patients in Group II at least one year.

I have stated that it is not always possible to distinguish between our Groups I and II cases by physical examination alone, one reason being that enlarged axillary nodes are palpable in but few of the Group II cases. This difficulty may be offered as an objection to our scheme for classifying mammary carcinomas. However, I may suggest that often it is just as difficult to distinguish between a benign and a malignant tumor of the breast by physical findings alone, and therefore it is necessary in a great many patients to employ some surgical procedures and microscopic examination to reveal the nature of neoplasm in the breast. Because of this uncertainty, I believe, it is the consensus among surgeons that when a tumor is found in a breast and there is not sufficient clinical evidence to determine whether it is malig-

one radiologist administered treatment more than five years ago according to one technic which was in vogue at that time. Both series have been classified on exactly the same basis according to the extent of the disease in each case. These two series should give a fair indication of what the prognosis would be for our different groups, as well as a just comparison of the results obtained in series of non-irradiated and irradiated cases. I would like to call attention to the fact that patients treated pre-operatively or only for post-operative recurrence or metastases are not included in the irradiated series and only those given immediate post-operative roentgen therapy for what may be called prophylaxis are considered, whether they had only one or more complete courses of treatment (Table III).

Between 1922 and 1931, I gave post-operative roentgen therapy to 100 of Dr Crile's patients. Unfortunately one patient did not return after her first course of treatment, and this case had to be discarded because we are discussing only traced cases, therefore, 99 cases remain in the irradiated series. I grouped these according to our classification and, interestingly enough, my conclusions conformed with those of Dr Graham, who previously had classed them independently. This shows that our plan is satisfactory and consistently applicable by different individuals. It happened that the irradiated series arranged itself as follows: Group I contained 21 cases (21.2 per cent), Group II contained 37 cases (37.3 per cent), and Group III contained 41 cases (41.5 per cent). It will be noted that the relative proportions for each group in this irradiated series were not the same as the rates for the groups in the total series discussed previously. The disproportion lies in Group II which is larger in the irradiated series (37.3 per cent) than in the total series (25.9 per cent) because, after operation, when axillary metastases were found, more of such patients were referred for roentgen treatment than when metastases were absent.

After arranging the 99 non-irradiated cases into their proper groups, we tried to

find among Dr Crile's traced cases an equal number in each group, but none of these are reported to have received irradiation at any time. We found that so many of Dr Crile's classifiable traced patients had had irradiation for one or another reason (85 per cent) that only 23 Group II cases were of use to make the comparison. However, there were more than enough for Group I (21) and exactly enough for Group III (41) cases. Therefore, in order to have the number of Group II cases equal in each series, I was forced to discard 14 cases from the irradiated series and chose to use the last 23 consecutive cases because more was known about these than the earlier cases.

In this way it became possible for me to study the prognosis and results of treatment in a total of 170 cases divided into non-irradiated and irradiated series, each series containing 85 consecutive cases, the cases in each series classified into three groups on the same basis according to the extent of the disease found to be present, and each different group in each series containing the same number of consecutive cases, every patient in each series operated upon by one surgeon and the cases in one of these series given post-operative roentgen therapy more than five years ago by one radiologist, using one technic. The two series were arranged for comparison as in Table IV.

According to this tabulation, 100 per cent of the patients in Group I survived for five or more years without evidence of the return of their disease following operation alone. It happened that one patient in the irradiated series died of cancer before that time. This case illustrates the possibility that axillary metastases may be absent and the disease disseminated through other lymphatic routes, for example, to the parasternal nodes, and therefore they are undetectable, or else axillary metastases escape the pathologist's examination. Either circumstance would occur but rarely.

It seems justifiable to conclude from this study that almost 90 to 100 per cent of the patients with mammary carcinomas but without metastases to the axillary lymph

whether or not operation did these patients any good or might have done harm to some patients when it is noted that almost half (43.8 per cent) were known to be dead within 12 months and almost three-fourths (73.1 per cent) within two years.

I believe that we are justified in concluding from the study that patients who present the classical evidences of advanced mammary carcinoma, thus placing them in our Group III, are incurable from the standpoint of operation alone, and that radical surgical procedures can do no good but actually may do harm by shortening their lives. And in addition, since irradiation apparently prolonged the lives, even of some of these patients with advanced disease, from three to six months by the comparatively modest quantities that they received five or more years ago, we may conclude that patients with such advanced disease will survive comfortably as long or longer if treated by irradiation alone and if they are not subjected to any radical surgical procedures.

I may say at this time that I have stated that the irradiated patients were treated more than five years ago and that they received very moderate treatment. I need not go into the details of the technic which have been published previously. It is sufficient to state that, by our newer methods of prolonged irradiation which makes it possible to administer a total quantity many times greater than previously, we may anticipate in the future much better results from roentgen treatment alone, or combined with the application of radium, or palliative operations for certain cases.

Having discussed what has been the prognosis and what seem to be the logical methods for treating mammary carcinomas according to the extent of the disease found in different groups of cases, it must be apparent that it is obligatory for clinicians and especially surgeons to try to differentiate by careful physical examinations between early or moderately advanced cases of carcinoma (Group I and Group II) and those that are advanced or incurable by operations (Group III). If this is done and patients with only

early or moderately advanced carcinomas (Group I plus Group II) are operated upon, the results from operation alone would be about 60 to 70 per cent five-year survivals. If when patients are found to have carcinomas still localized in the breast but with axillary metastases, they are given irradiation post-operatively, the five-year survival rate will be even greater. But the important problem is to recognize the 50 per cent of patients who have incurably advanced (Group III) carcinomas and not to subject them to radical operative procedures but to treat them by irradiation alone. The clinical manifestations of incurable mammary carcinoma are

- I Manifestations affecting the skin
 - (a) Edema (pig or orange skin) even of moderate degree,
 - (b) Brawny red induration and inflammation,
 - (c) Multiple nodules,
 - (d) Ulceration
- II Manifestations affecting the breast
 - (a) Edema,
 - (b) Diffuse infiltration,
 - (c) Multiple secondary tumors,
 - (d) Fixation of the breast or tumor to chest wall
- III Manifestations of metastases
 - (a) Axillary lymph nodes, numerous, or fixed,
 - (b) Supraclavicular metastases or edema of the arm,
 - (c) Distant metastases (lungs, bones, other organs)

CONCLUSIONS

1 A classification for cases of mammary carcinomas is desirable and should be adopted. It should be based upon the clinical and pathological evidences of the extent of the disease.

2 A classification is suggested which divides cases into three groups, each of which is shown to represent different prognosis and indications for therapeutic procedures.

3 The early Group I cases with localized, movable tumors in the breast and without axillary metastases should be operated upon but not irradiated. Almost 100 per cent of these patients will survive for five years. This group comprises about 30 per cent of all cases.

nant or benign, it should be excised *in toto* for immediate examination microscopically. If the tumor is proved to be benign, no other operation is necessary. If it is malignant, more radical surgical procedure should be performed immediately to remove more tissue, including the axillary contents, because of the uncertainty of the presence of axillary metastases even by the gross examination at operation, and conclusions about the extent of the disease and prognosis must be established after careful microscopic examination of every lymph node.

Therefore it is evident that it is unnecessary from the standpoint of prognostication to distinguish between Group I and Group II cases of mammary carcinoma on the basis of clinical findings alone, because most patients with localized tumors in the breast are subjected to operation anyway, not only in order to determine whether the growth is benign or malignant but to indicate what therapeutic procedures should be instituted, this depends upon whether or not malignant disease has been found to have metastasized to the axillary nodes.

Our Group III cases present a problem entirely different from that in the other

would have lived as long if nothing whatever had been done for them. It is well known that not all women with mammary carcinomas will die from their disease in five years even if they are not treated. The average natural duration or life expectancy for a woman with mammary carcinoma is thought to be about three years, but a few have been known to live 20 or more years without treatment.

It might appear from this tabulation of five-year survivals that the patients in Group III were not benefited by either operation or irradiation. The question may be answered by determining what happened during the first three years after operation (Table V). It was found that those lost or dead within six months comprised about one-third (34.1 per cent) of the non-irradiated series and one-tenth (9.7 per cent) of the irradiated series. One might inquire if the difference might be explained on the basis that not so many patients would be lost who continued to come for irradiation treatment from time to time, but this is not the explanation, because only a few of the patients in the non-irradiated series were actually lost in the first six months after operation (7.3 per cent) and most of them (26.8 per cent) were known to be

TABLE V — COMPARISON OF CASES LOST AND THOSE DEAD WITH CANCER IN 41 NON-IRRADIATED GROUP III CASES AND 41 IRRADIATED GROUP III CASES

	(Results in Numbers and Percentages)							
	1-6 Months		7-12 Months		13-24 Months		24-36 Months	
	No	Per cent	No	Per cent	No	Per cent	No	Per cent
Lost trace with cancer								
Non irradi	3	7.3	4	9.7	5	12.2	5	12.2
Irradi	0	0	0	0	0	0	2	4.8
Known died with cancer								
Non irradi	11	26.8	18	43.8	30	73.1	32	78.0
Irradi	4	9.7	18	43.8	26	63.4	31	75.5
Lost or died with cancer								
Non-irradi	14	34.1	22	53.6	35	85.3	37	90.3
Irradi	4	9.7	18	43.8	26	63.4	33	80.5

two groups. The prognosis for these advanced cases may be determined by noting that not one of our 82 Group III patients comprising both the non-irradiated and irradiated series survived for five years without evidence of disease.

A few of these patients survived five years but still had cancer. It may be that they

dead, but no patient who received irradiation was lost, and all (9.7 per cent) previously mentioned were known to have died. Therefore, the irradiation even of these patients with advanced disease apparently did prolong some lives as proved again by the other intervals tabulated. This study also brings up the question of

PRACTICAL METHODS OF REDUCING THE CANCER DEATH RATE¹

By EDWARD H. SKINNER, M.D., *Kansas City, Mo*

RADIOLOGY has arisen within the period of years that parallels the development of a renewed interest in the study of cancer. Many have ascribed to radiology the part of having been the determining factor or at least furnishing the urge for the renewal of a practical attack upon cancer. The amount of research work is tremendous. Clinical reports of progress would fill volumes, but it is time certainly for us to apply and to translate into human equations many of these research and clinical facts.

It probably seems too formidable to attempt any practical attack through genetics because we would not accomplish much within our own lifetime, yet there are a great many things we do know that should be applied by all physicians. Surely radiologists should be the leaders in enthusing, translating, promoting, and propagandizing cancer control to the whole profession because radiology has provided some measure of hope and cheer to the cancer problem through radiation therapy and enhanced the surgical attack by roentgen diagnosis.

With the belief that the control and treatment of cancer are professional problems, with the idea of increasing the hopes and ambitions of physicians in early diagnosis and successful cure, and with confidence that the advances in cancer knowledge warrant the banishment of folk-lore fear and professional pessimism, it is interesting to translate some of the statistics and research facts into human equations which will be applicable in the daily practice of all physicians.

Let us erect a declaration of faith in certain basic cancer facts. Let these facts serve as flags which symbolize our faith.

First, *cancer is a preventable disease*.

¹ Presented before the Radiological Society of North America at the Twenty second Annual Meeting, Cincinnati, Nov. 30-Dec. 4, 1936.

This was brought very forcibly to my attention at one time, and the anecdote may serve to impress this fact. I was sitting next to the great pathologist, Dr. James Ewing, at a dinner and was inviting him to Kansas City to a clinical conference in which we intended to program a "Symposium upon Diseases of Degeneration." Ewing said, "I am not interested at all. I cannot agree that cancer is a disease of degeneration. Better confine your program to heart, kidney, and syphilis because cancer is a preventable disease."

Whenever we put a disease in the preventable category, we then know that we can learn to avoid and control that disease even before we find its cause or its cure.

In this morning's newspaper *Muir*, the great English authority upon leprosy, reports that leprosy probably will be eradicated entirely from the face of the earth before the cause is found. It may be likewise with cancer. It seems unreasonable to insist that failure to find the cellular, biochemical, parasitical, or chimerical cause of cancer precludes the application of proven measures of prevention, control, and cure.

Let us say that the first flag of our attacking army is that *cancer is a preventable disease*.

Let us take another very simple statement for our second flag. Let us agree that *cancer starts from a single spot*, perhaps unicellular, in tissue or organ. It does not start as a tumor, or ulcer, or grossly invading growth. Such displays are late expressions or developments of the small early lesion that we should have been able to recognize. We must be more suspicious and insist upon proof of the innocence of visible and invisible tissue displays of altered function. Cancers are microscopic before they become palpable or visible. Visible cancers do not produce pain before they are palpable. Many cancers that

4 The patients in Group II with moderately advanced, localized, movable tumors in the breast and only a few axillary lymph node metastases should have radical, operative removal of as much of the diseased tissue as possible and, in addition, they should be given irradiation post-operatively. About 50 per cent of such patients will survive five years if operation is the only treatment and at least 75 per cent will survive as long if irradiation is given. This group comprises about 25 per cent of all cases.

5 The patients in Group III with clinical manifestations of incurability should not be subjected to radical surgical procedures. No patient will survive for five years without evidence of cancer. These patients should be treated by irradiation alone to prolong their lives. This group comprises about 45 per cent of all cases.

6 A thorough search should be made for the clinical manifestations of incurability which are enumerated, and patients

with any of them should not be subjected to a radical operation.

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facts and fancies is far more important than lay education because if physicians are not practising the early diagnosis of cancer, what good does it do to advise potential or inquiring patients to consult their physicians?

These are the flags which symbolize our faith in certain facts regarding cancer. You are all familiar with research facts and clinical facts which support each one of these contentions. We must translate more of these facts to the general profession. It must absorb them. It must use them.

We should look at some old surgical premises with new vision. It has been an accepted policy that a surgeon must be absolutely sure of the presence of mammary malignancy before performing a radical mastectomy. Consequently, the mortality for mammary malignancy remains unnecessarily high. Why not demand some scientific proofs of the innocence or benignity of a breast tumor and sacrifice a few innocent tumors in breasts? Then we will surely have excised all of the malignant ones!

Again, if the cancer facts that we know regarding the development of cancer at the cervix were thoroughly exercised within the practice of every physician, we could cut down the incidence of cervical cancer. If these women were taken care of in their post-natal period in a way that is proper and justifiable, if the irritation to tissues which results from the lacerations and infections were removed, and if we treated adequately the pre-cancerous stage of a malignancy of

the cervix, we would avoid the horrible morbidity and mortality of this preventable group of cancers.

I am not at all in favor of the development of huge cancer centers. They are all right in well-populated communities, but they are not going to serve the people all over the country. It is far more practical for us to bring a cancer service to the patient than to insist that the patient must be transported to one specialist or one institution.

If the profession will attack cancer in its early stages, there is not the necessity for these large institutions. If this cancer problem is attacked upon the facts that we now know, you and I will be using our roentgen apparatus for diagnostic purposes rather than for treatment purposes. I can't help but feel that the present tremendous amount of roentgen therapy that is being done for late cancer will be looked back upon some time as just another interesting phase in medical history. *One candle power of intelligence applied in early diagnosis or in the elimination of the known pre-cancerous situation will be far better than any million volts of irradiation for late cancer displays.*

At the Battle of Gettysburg a drummer boy too small to fight was carrying the flag. He saw the enemy retreating beyond the line of the company trenches. The soldiers called to him and said, "Hey! Come on back. Bring the flag back to the line!"

But the boy yelled, "No! Bring the line up to the flag!"

defy direct vision become indirectly visible by roentgen examination

For the third point, let us rally round the flag symbolizing *chronic or persistent irritation* as the most useful and practical causal element in cancer. The single, repeated, or continuous insults to tissues by seemingly innocent bruises (certain breast cancers), the chronic pyogenic insults (endocervicitis), parasitic insults (actinomycosis), the direct injury by trauma (osteogenic sarcoma), insults by foreign bodies (pipe, betel nut, occupation). The persistent or renewed activity of unwelcome or uninvited congenital tissue remnants, growth-trends and the complicated sequential abnormal tissue reactions outside normal physiology—these may be regarded as irritations or insults to the normal metabolism of cells. Careful history-taking brings out some degree of chronic irritation and organic injury in a large percentage of cancers.

As another divisional flag let us take this *the early diagnosis and prompt eradication* of the lesion by surgery or radiation therapy will promote a decline in cancer mortality.

Here is a field in which radiology can arrogate to itself a great deal of the progress in cancer diagnosis. We have heard surgeons talk for so many years upon inaccessible cancer—it is accessible cancer when visible or palpable. We should include in that accessible field those types of malignancy which are visible through a simple instrument like a scope. Roentgen examinations serve to make visible those changes in the internal organs which are evidence of a malignant disturbance. In order to visualize an early malignancy in the brain, we use the ventriculogram or encephalogram. In pulmonary tissues before the microscopic evidence is rescued by a bronchoscope, the roentgen examination of the lungs serves to locate the site from which the biopsy is secured.

The directly visible, palpable, and easily biopsied field of cancer includes skin, lip, mouth, throat, and breast. The rectum

and vagina are also palpable and become visible directly by the speculum.

The indirectly visible field, or the so-called inaccessible field, includes the brain, lungs, stomach and colon, kidneys, bladder, and bones. The indirect visibility is accomplished by roentgen examinations combined with artificially produced opacity in otherwise homogeneous tissues through biochemical or displacement methods.

Another flag *biopsy study by pathologists* has displaced the macroscopic evidence of the surgeon. Simple biopsy rescue is possible in all visible and palpable lesions of the skin, lip, mouth, cervix, rectum, or what is distinctly the preventable field of malignancy. The biopsy rescue becomes a more formidable but not impossible measure in breast, brain, larynx, lung, stomach, and colon. There should be more dependence upon the roentgen interpretation of bone malignancy than surgeons seem to afford us.

Another flag *treatment principles* are assuming new alignments, depending upon *tumor grading and sensitivity* to radiation. Total surgical excision of cancerous growths is jealously maintained and with a more courageous completeness, but the partial extirpation of any cancer is condemned. Surgical exposure for intimate radium therapy is a valuable venture. The use of well-executed radium therapy for those superficial malignancies to skin, mouth, lip, and cervix has become rather universal, but there must be insistence upon the exhibition of lethal and homogeneous radiation therapy.

The simplicity, comfort, and low expense of radium therapy render it increasingly available throughout the world. Roentgen therapy occupies a distinct field, especially in inoperable and incurable malignancy. It may afford relief from pain and may delay exitus, and it continues as a research problem of gradually increasing merit.

The last flag *that educational propaganda* be divided between that which is *professional* and that which is *popular*. The professional appreciation of cancer

soft tissues The fact that by keeping the teeth short in cancer-susceptible mice it has been possible to prevent these cancers, seems to demonstrate that the "irritation" factor is here of influence as an accelerator or an external causative agent

I am presenting the report of an entire strain of mice, comprising 650 individuals, derived from the original mating of two individuals, and carefully analyzed by inbreeding for nine generations The object of this study has been to determine the behavior of malignancy as a biologic character, and to demonstrate the influence and method of heredity in the occurrence of malignancy and in its localization

I remind you that these tumors are not produced by any experimental procedures whatever They are all spontaneous tumors, arising naturally in the life of the animals and developing without any interference of any sort, at any time Every animal is kept in hygienic conditions under controlled diet and temperature Every mouse is permitted to live out its natural life span and thus to show all of its natural cancer tendencies and all of the systemic changes wrought by cancer None is killed Since the first death in this study, every mouse has been autopsied as soon as possible after death and every suspicious tissue has been examined histologically for malignancy These tissues and slides are all in permanent museum Every precaution is taken to see that no mouse is destroyed by postmortem changes To this end, all are examined at least once daily, and every sick mouse three times daily None has ever been discarded without autopsy No cancers are reported without confirmed microscopic diagnoses of malignancy Thus every precaution is taken against these important and very common chances for error

I wish to remind you also, that whatever reports are made concerning the experimental production of tumors by various agents, there are included in my studies close to 100,000 individual tumors in mice to which nothing has been done These spontaneous tumors will have to be

taken into account in the consideration of any experimentally applied external agent as the efficient cause of cancer

The theory here offered as an explanation of the mode of cancer inheritance is as follows (1) Malignancy is an abnormal type of proliferation transmitted as a localized recessive character, each type of malignancy being a unit character and capable of suppression by a dominant allelomorph, that is, one unit recessive character for carcinoma, one unit recessive character for sarcoma, one unit recessive character for leukemic disease (2) Localization factors as physiologic characters of such a nature that they provide the occasion for malignancy where they occur in tissues by heredity capable of malignancy, and when the necessary interrelation with the external causative factor arises, if such there be

The causes of cancer then would be (1) One unit recessive genetic factor for each type of malignancy (carcinoma, sarcoma, leukemic disease), not just one unit character for all types of malignancy (2) One unit recessive genetic localization factor determining each site of malignancy for the type—mammary gland, or lung, or body-wall, for example (3) External causative factors perhaps (environmental or intra-organic) (4) Metabolic relationships (5) Longevity or ability to live into the age for high cancer probability

Failures in the expected occurrence of cancer may thus be due to

- (1) Failure of assortment between the recessive factor for malignancy and the recessive localizing factor
- (2) Failure of a possible external factor
- (3) Unfavorable metabolic conditions (intercurrent and degenerative diseases)
- (4) A short life span

The symbols used in the theory are as follows—be patient with these so that the charts will be meaningful

FACTORS FOR MALIGNANCY

I Epithelial malignancy, a recessive unit character represented by d_1

THE RELATION OF HEREDITY TO THE OCCURRENCE OF CANCER

By MAUD SLYE, *Chicago*

Director Cancer Laboratory Sprague Institute, and Associate Professor of Pathology,
University of Chicago

WISH in the time allotted to me through your generosity to present two phases of the cancer problem, namely, the working out of a very exact mathematical theory which explains to a nicety not only the occurrence but also the localization of cancer in my stocks of mice, and second, to suggest ways in which there could be a practical application of these findings to the human cancer tragedy

I beg that you will give attention to the charts I shall present and not look upon them as a piece of work of academic interest only, for they show and explain the breeding out of breast cancer through nine generations of mice. This complete elimination of breast cancer from an entire family of mice tested through so many generations, is highly significant when one considers the fact that breast cancer is so overwhelmingly the cancer menace of mice that geneticists and research workers, other than myself, rarely report upon any other form of mouse malignancy. In terms of human life, these nine generations would mean over six hundred years of complete freedom from breast cancer, and the exemption from cancers which I have obtained in some strains of mice throughout the twenty-seven years of this work would, in terms of human experience, mean a freedom from cancer of some three thousand years.

Cancer is not an academic problem maintained for the bickerings of some geneticists who do not happen to agree on this or that detail of the method of cancer heredity. It is a social problem, a vast social menace, and it is time something was done to stop its increase before it moves up to be the first of all death causes. It is to such an end that my work has gone through every storm it has met.

I would say in passing that I have an exhibit which gives the exact data concerning every mouse in the strain here reported, although only a few of the charts can be included herein with their analyses and explanations. I shall be glad to show this exhibit at any time to any one interested therein. Let me first show you the theory.

There are apparently two causes operative in the production of cancer: first, inherited susceptibility (that is, susceptible soil) and second, perhaps, irritation or chronic stimulation by particular hormones or so-called carcinogenic agents, or by trauma, or by other causes of the types fitted to induce it. In mice resistant by heredity, irritations and traumas incident to life in this laboratory have never induced cancer, while in mice susceptible by heredity to only one location of cancer, irritation or stimulation applied to other parts of the body have to date failed to induce neoplasms in these insusceptible tissues.

In some malignancies under study, when irritation to the locally susceptible tissues has been avoided, cancer has not occurred even in susceptible strains. For example, uneven teeth are frequent in mice; consequently they strike upon the soft tissues of the mouth and jaw. This seems to be one of the possible external factors inducing cancer of these tissues. Many mice in cancer-susceptible strains have developed malignancy at the point of contact of such teeth. I have not yet determined whether the crooked teeth or the beginning of cancer is the first cause of this relationship. In carcinoma-susceptible mice the result is carcinoma. In sarcoma-susceptible mice the result is sarcoma. In non-susceptible strains the result is never malignancy, but only inflammatory or septic changes have been found. It has seemed possible also to prevent such cancers in susceptible mice by keeping their teeth short and thus preventing the constant traumatism of these

¹ Presented before the Radiological Society of North America at the Twenty-second Annual Meeting at Cincinnati, Nov 30-Dec. 4, 1936

than would the occurrence of chronic nephritis in the same mouse with breast carcinoma. Carcinoma remains unit recessive, breast location remains unit recessive. Nor does it complicate the genetic pattern for sarcoma or for leukemic disease, both of which remain unit recessive. The complex genetic pattern applies to the occurrence of breast carcinoma and body-wall sarcoma, for example, in the same mouse, which would give a genetic pattern of four unit recessives, one for carcinoma, one for the breast, one for sarcoma, one for the body-wall, and so on, for the combination of different types and sites of malignancy in the same mouse.

Line 7 is one of 10 crosses made between red females from one strain, and albino males from an unrelated strain. The entire experiment involves between 4,000 and 5,000 mice. The females were sisters from a strain *carrying a low percentage of malignancy*. Of these malignancies, 20 per cent were mammary gland carcinoma, 66.6 per cent were leukemic disease, and 6.7 per cent were mixed tumors of the thyroid. The ancestral lines that lay behind the strain from which these females came showed lung tumor, ovarian tumor, and subcutaneous tumors, but no body-wall tumors in any of its branches.

The parent males were brothers from a strain *carrying a high percentage of malignancy*. Of these malignancies, 16 per cent were carcinoma of the mammary gland, 38.7 per cent were carcinoma of the lung with a few carcinomas in other organs, 25.8 per cent were sarcomas chiefly in the body-wall and subcutaneous tissues, 22.5 per cent were leukemic disease.

The parent females were obviously able to transmit the localization factors for each of the various sites shown in the hybrid crosses, with the exception of body-wall, a tumor site that appears nowhere in any of their ancestral strains. The localization factor for body-wall was carried in by the males. As body-wall malignancy nowhere appeared in the F_1 in any of the 10 hybrid crosses, the parent females evidently carried only the dominant allelomorph and

were not responsible for the localization of body-wall malignancy in the hybrid strains. In Line 7, 32.9 per cent of all its malignancy was body-wall sarcoma.

Line 7 was originated by a red female with carcinoma of the mammary gland crossed with an unrelated albino male dying of pneumonia, without cancer. There was only one offspring from this cross, a female dying of pleuritis at an advanced age, without cancer. Mated back with her father to make the strain, she produced a line carried through nine generations, which neither in F_1 nor in any of the succeeding generations ever produced a carcinoma of the mammary gland or any other tumor of the mammary gland. Whereas, when the same female was mated with a male from Line 1, which carried a rather high percentage of mammary gland carcinoma, the F_1 showed mammary gland carcinoma, and breast cancer persisted throughout the three generations from that cross. The parent male from Line 1 would seem responsible for the introduction of mammary gland carcinoma. There is no evidence here of an extra-chromosomal influence, either in breast cancer or any other form of malignancy.

Age must be taken into consideration in all these genetic studies. The test age, 17 months, was established for this Line 7, which is six months lower than the average age for malignancy in this very long-lived line. That is, all mice living to the age of 17 months are included in the findings. The average age for the occurrence of ovarian adenoma and carcinoma, lung carcinoma, and sarcoma of the body-wall and subcutaneous tissues, was so high that the test age of 19 months was established in estimating the probabilities for these types of malignancy. All mice showing cancer are included in the findings. The only non-cancerous mice excluded are those dying under test age. The average non-cancer age of the mice included in the findings was 22.5 months, the average cancer age was 22.3 months, nearly identical.

Only 12.2 per cent of the females died

II Connective tissue malignancy, a recessive unit character represented by d_1

III Leukemic type malignancy, a recessive unit character represented by d_2

The dominant allelomorph for each of these recessive characters is represented by the corresponding capital. The possible distribution and combinations of these types would be

carc sarc leuks carc-leuks carc-sarc
sarc-leuks carc-sarc-leuks

FACTORS FOR LOCALIZATION

I Epithelial localizing factors recessive unit characters for lung, l, mammary gland, m, ovary, o. The dominant allelomorphs for these characters are represented by capitals

II Connective tissue localizing factors recessive unit characters for body-wall, b, and subcutaneous, s, with dominant allelomorphs B and S

III The localizing factors for leukemic type are not analyzed, due to disagreements in the pathology of these types, and to the frequent apparent merging of one into the other. These factors represent the common sites of malignancy in this strain

The following are the possible assortments of unit recessive characters for the localization of malignancy. I ask you to attend to this in order to see how difficult it is to prove these things

I A two-character assortment (one for malignancy and one for localization) lung carcinoma, d_1l , ovarian malignancy, d_1o , mammary gland carcinoma, d_1m , body-wall sarcoma, d_2b , subcutaneous sarcoma, d_2s

II A three-character assortment (one for malignancy and two for localization) for the simultaneous occurrence in the same mouse of carcinoma of the lung and ovarian adenoma or carcinoma, d_1lo , of sarcoma of the body-wall and sarcoma of the subcutaneous tissues, d_2bs

III A four-character assortment (two for malignancy and two for localization) for example, the simultaneous occurrence in one mouse of carcinoma of the lung and

sarcoma of the body-wall would require the assortment, d_1d_2lb , of carcinoma of the lung and sarcoma subcutaneous, d_1d_2ls , adenoma of the ovary and sarcoma body-wall, d_1d_2ob , of adenoma or carcinoma of the ovary and subcutaneous sarcoma, d_1d_2os

All four of these sites should be found also assorting with leukemic disease, and this would require the four-recessive assortment for their concurrent appearance. There should then be found mice with both carcinoma of the lung and leukemic disease, sarcoma of the body-wall and leukemic disease, sarcoma of the subcutaneous tissues and leukemic disease, and ovarian adenoma and leukemic disease

IV A six-factor assortment which would involve the occurrence in one mouse of carcinoma, sarcoma, and leukemic disease. This would require at least the assortment of six recessive characters, three for malignancy (that is, one for each type of malignancy) and three for localization (that is, one for each location). All of these difficult combinations must be found for the validation of this theory. An examination of the totals for the entire line will show that all of these combinations were found

Where the genetic pattern for the concurrent appearance of these characters is very complicated, that is, in a mouse with many forms of malignancy, it will readily be seen that the necessary assortment of these characters is rare, by the laws of chance. Not only is the genetic pattern complex, but the added complexity of the inter-relation with possible external causative factors, and the age incidence for the different types of tumor, make them combinations difficult to obtain. The only considerable failures in my totals lie in these complex categories. And in spite of these difficulties all of these combinations required for the validation of the theory were found

Note that this complicated genetic pattern for the occurrence of multiple types and sites of malignancy in the same mouse does not complicate the genetic pattern of breast carcinoma, for example, any more

Chart 87

Line 7
F₁

Strain $\frac{3333II}{3333I\gamma'}$
 $\frac{\gamma 2}{\gamma 3} \star \gamma \gamma II$

	Carcinoma Mammary gland Metastases in Lymph Node, Bronchitis	Bronchitis, Pneumonia Blood Clot in Lymph Node
\star Red ♀ 90501	Alb ♂ 86725	
C Age 1yr 2mo 11days	H Age 10mo 27days	

F ₁	I Daughter	F ₁	0 Sons
Red ♀ 102374	Suppurative Myocarditis Pericarditis, Pleuritis Age 1yr 7mo 1day		
	Gen. carc Het sarc, d' D ² D ³ Leuks, d' d ² d ³		
	Spotting factors LB 50M l b 50m		

Genetic Analysis of Parents

Factors, Malignancy ♀ Extracted carc d' D² D³
♂ Het carc, Sarc, Leuks d' D² D³
d' d² d³

Factors, Spotting ♀ LB 50m ♂ l b 50M
♀ LB 50m ♂ l b 50M

Probabilities NC · Carc
5 5

Chart 87 Note that although the parent ♀ 90501 has breast carcinoma the daughter ♀ 102374, has no breast cancer The tendency to the breast as location for carcinoma is here negated by the dominant allele morphs MM carried in by the parent ♂ 86725

The findings are in accord with the probabilities for the theory

The formulae for both malignancy and localization of ♀ 90501, ♂ 86725, and ♀ 102374 are shown

under test age, so that most of them were subjected to the test of age and were able to demonstrate their genetic potentialities. Of the males, however, 42.8 per cent died under test age, of fighting and septic wounds, so that nearly half of the males were eliminated from the age test, and undoubtedly many potentially cancerous males were eliminated in this considerable slaughter in early life. For the theory 81 NC ♀ and 71 NC ♂ were possible

for the entire line of 650, or 152 NC. The findings for the tested 477 mice gave 155 NC, or a failure of malignancy in only three mice for complete accord with my theory.

In the summary of the assortment of malignancy and the characters for the localization of malignancy, the findings for carcinoma and sarcoma showed no shortage of tumors for the theory in mice living into test age. (See Charts)

CHART 87

LINE 7, F₁

Parents		Malignancy factors		Localization factors*	
		d ₁ D ₂ D ₃	d ₁ D ₂ D ₃	m L O B S	m L o B s
par ♀ (90501)	carc m gl				
	14 mo 11 da				
par ♂	pneumonia (86725)				
	10 mo 27 da	D ₁ D ₂ D ₃	d ₁ d ₂ d ₃	M I O b S	M I O b S

* The localization factors for leukemic type are not included in the analyses because of disagreements in the pathology of these types

No offspring 1 ♀ dying at 19 mo 1 da of sup myocarditis pericarditis pleuritis
No in findings 1 ♀

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (1 1)	NC	Carc
For 1	5	5
Findings for 1	1	0

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 1	FINDINGS
carc m gl (d ₁ m)	0	0
carc. lung (d ₁ l)	0	0
adenoma ovary (d ₁ o)	0	0
sarc body-wall (d ₁ b)	0	0
sarc subcut (d ₁ s)	0	0

Three recessives (1 for malignancy 2 for localization)

m gl lung (d ₁ ml)	0	0
m gl-ovary (d ₁ mo)	0	0
lung-ovary (d ₁ lo)	0	0
bw-sub (d ₁ bs)	0	0

*Four recessives (2 for malignancy 2 for localization) carc sarc**

m gl bw (d ₁ d ₂ mb)	0	0
m gl-sub (d ₁ d ₂ ms)	0	0
ov-bw (d ₁ d ₂ ob)	0	0
ov sub (d ₁ d ₂ os)	0	0
lung-bw (d ₁ d ₂ lb)	0	0
lung-sub (d ₁ d ₂ ls)	0	0

* The probabilities for carc-leuks and sarc-leuks are not estimated

This F₁ ♀ (102374) was classified as genetic carc with dominant localization factors for the epithelial malignancies. She was heterozygous to sarc. and leuk

d₁D₂D₃ M L O B S
d₁ d₂ d₃ m l o b s

This F₁ ♀ (102374) had one back-cross litter by her father this litter was inbred to form Line 7 Br I II and III. She was later bred with an F₁ ♂ from Line 1 forming Line 7y x 1 y⁴. The first generations of these two crosses are compared. It is noteworthy (1) that ♀ 90501 with breast carcinoma crossed with ♂ 86725 produced no breast carcinoma, (2) that her daughter 102374 crossed with her father ♂ 86725 produced a family which inbred for nine generations and, yielding 34 females never showed breast carcinoma. (3) that this same female 102374 outbred with a male from a family showing breast carcinoma produced another family in which breast carcinoma occurred in the F₁ and persisted through three inbred generations.

Chart 88

Line 7
F₂ Back Cross of F₁ ♀ 102374
with her father ♂ 86725

Strain $\frac{3333II}{3333IyI}$
 $\frac{y2}{y3} \star yy^{II}$

Suppurative Myocarditis
Pleuritis, Pericarditis

Bronchitis, Pneumonia
Blood Clot in Lymph Node

F₁ Red ♀ 102374 Parent Alb ♂ 86725
Gen C Age 1 yr 7 mo 1 day H Age 10 mo 27 days

Sp. cell sarc of mes, intest.,
ovaries, kidney, uterus, pancreas,
liver muscles lymph nodes

F ₂ 4 Daughters		F ₂ 4 Sons	
*Red ♀	107201	*Red ♂	108430
Br I	Age 1 yr 9 mo. 8 days	Br I	Age 1 yr 10 mo 19 days
BI ♀	94677	*Alb ♂	106292
Br II	Age 8 mo	Br II	Age 1 yr 8 mo 9 days
Alb ♀	100703	*Alb ♂	113166
Br III A	Age 1 yr 2 mo 10 days	Br III A B	Age 2 yr 5 mo 11 days
Alb ♀	108024	Red ♂	Dead in infancy
Br III B	Age 1 yr 10 mo 4 days		

NC : C
Prob for 7 — 19692 : 5 0324
Prob for 5 — 14067 : 3 5949
Findings for 5 — 1 . 4

Chart 88 Note that when F₁ ♀ 102374 is mated back with her father 86725 no breast cancer occurs in the offspring Nor did it ever occur again in this Line 7 made by the back-cross of 102374 with her father 86725 although this line was carried through nine generations and numbered 650 mice The findings are in accord with the probabilities for the five mice living to test age

Obviously no cross was ever made between two mice heterozygous to breast location, that is, both mice carrying $\frac{M}{m}$ in the genetic formula

CHART 88

LINE 7, F₂

Parents F₁ ♀ (102374) pleuritis 19 mo 1 da
(gen carc)

par ♂ (her father) pneumonia 10 mo 27 da
(80725)

Malignancy

d₁D₂D₂d₁d₂d₂D₁D₂D₂d₁d₂d₂

Localization

M L O B S

m l o b s

M I O b S

M I O b S

No offspring 7 4 ♀ 3 ♂ (2 NC ♀ dead under age)

No in findings 5 2 ♀ 3 ♂

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (9 23)

NC

C

For 7

1 9692

5 0324

For 5

1 4007

3 5949

Findings for 5

1

4

♀ 1 1

♂ 0 3

Prob

NC

Carc

Sarc

Leuks

C-L

C-S

S-L

C-S-L

For 7

1 9692

1 9692

6564

6564

6564

6564

2188

2188

For 5

1 4007

1 4007

4689

4689

4689

4689

1563

1563

Findings for 5

1

2

1

1

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 7, 4 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	1 75	1 25	2
ovary	0	0	0
body-wall (7 1)	875	625	1
subcut	0	0	0
	<hr/> 3 625	<hr/> 1 875	<hr/> 3

Four recessives (2 for malignancy 2 for localization)

lung-bw (31 1)

2188

1563

0

Summary of malignancy (factors for malignancy considered alone) based on no of individuals.

carc	3 5	2 5	2
sarc	1 75	1 25	1
leuks	1 75	1 25	1
	<hr/> 7	<hr/> 5	<hr/> 4

Short 1

Summary of localization (assortment of malignancy and localization factors) based on no of tumors

carc	1 75	1 25	2
sarc	875	625	1
	<hr/> 2 625	<hr/> 1 875	<hr/> 3

Short 0

Chart 88

Line 7

 Strain $\frac{3333II}{3333IYI}$
 $\frac{Y2}{Y3} \star YY II$

 F₂ Back Cross of F₁ ♀ 102374
 with her father ♂ 86725

	Suppurative Myocarditis Pleuritis, Pericarditis	Bronchitis, Pneumonia Blood Clot in Lymph Node
F ₁ Red ♀ 102374	Parent Alb ♂ 86725	
Gen C Age 1 yr 7 mo 1 day	H Age 10 mo 27 days	

 Sp. cell sarc of mes, intes,
 ovaries, kidney, uterus, pancr
 liver, muscles lymph nodes

F ₂		F ₂		4 Sons	
*Red ♀	107201	*Red ♂	108430	Carcinoma Lung	
Br I	Age 1 yr 9 mo 8 days	Br I		Hemorrhage in Mediastinum	
				Age 1 yr 10 mo 19 days	
Bl ♀	94677	*Alb ♂	106292	Leukemia	
Br II	Acute Colitis, Appendicitis Fatal Hem. from Thoracic Aorta	Br II		Age 1 yr 8 mo 9 days	
	Age 8 mo				
Alb ♀	100703	*Alb ♂	113166	Carcinoma Lung	
Br III A	Colitis, Peritonitis	Br III A B		Hemorrhage in Lung	
	Age 1 yr 2 mo 10 days			Age 2 yr 5 mo 11 days	
Alb ♀	108024	Red ♂		Dead in infancy	
Br III B	Chronic Nephritis				
	Age 1 yr 10 mo 4 days				

	NC	:	C
Prob for 7	—		19692 . 5 0324
Prob for 5	—		14067 . 3 5949
Findings for 5	—		1 . 4

Chart 88 Note that when F₁ ♀ 102374 is mated back with her father 86725 no breast cancer occurs in the offspring Nor did it ever occur again in this Line 7 made by the back cross of 102374 with her father 86725 although this line was carried through nine generations and numbered 650 mice The findings are in accord with the probabilities for the five mice living to test age

Obviously no cross was ever made between two mice heterozygous to breast location, that is, both mice carrying $\frac{M}{m}$ in the genetic formula

CHART 107

LINE 7y x ly⁴, F₁

Parents par ♀ from Line 7 F₁
 sup pleuritis 19 mo 1 da
 (gen. carc) (102374)

Malignancy factors
 d₁D₂D₃
 d₁d₂d₃

Localization factors
 M L O B S
 m l o b s

par ♂ Line 1, F₁
 pseudoleukemia 26 mo 6 da
 (gen. sarc) (110567)

D₁d₂d₃
 d₁d₂d₃

M L O B S
 m l o b s

No offspring 23 14 ♀ 9 ♂ (3 NC ♀ 4 NC ♂ died under age)
 No findings 16 11 5 (16 in test age probabilities)

Theory NC C
 1 7

Distribution of malignancy (factors for malignancy considered alone)

Probabilities	NC	C	
For 23	2 875	20 125	
For 16	2	14	
Findings for 16	4	12	♀ 3 8 ♂ 1 4

Prob	NC	Carc	Sarc	Leuks	C-L	C-S	S-L	C-S-L
For 23	2 875	2 875	2 875	2 875	2 875	2 875	2 875	2 875
For 16	2	2	2	2	2	2	2	2
Findings for 16	4	3	4	4	0	1	0	0

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 23 14 ♀	PROB TEST AGE	FINDINGS
m gl (7 1)	1 75	1 375	1
lung (7 1)	2 875	2	3
ovary	0	0	0
body-wall (7 1)	2 875	2	2
subcut (7 1)	2 875	2	3
	<hr/> 10 375	<hr/> 7 375	<hr/> 9

Three recessives (1 for malignancy 2 for localization)

lung m gl (31 1)	4375	3438	0
lung ov	0	0	0
bw-sub (31 1)	7188	5	0
	<hr/> 1 1563	<hr/> 8438	

Four recessives (2 for malignancy 2 for localization)

m gl-bw (63 1)	2183	1719	0
m gl sub (63 1)	2183	1719	1
lung bw (63 1)	3594	25	0
lung sub (63 1)	3594	25	0
	<hr/> 1 1564	<hr/> 8438	<hr/> 1

Summary of malignancy (factors for malignancy considered alone) based on no. of individuals

carc (d ₁)	11 5	8	4
sarc (d ₂)	11 5	8	5
leuks (d ₃)	11 5	8	4
	<hr/> 34 5	<hr/> 24	<hr/> 13

Short 11

Summary of localization (assortment of malignancy and localization factors) based on no. of tumors

carc	4 635	3 375	4
sarc	5 75	4	5
	<hr/> 10 375	<hr/> 7 375	<hr/> 9

Short 0

Chart 107
 Strain $\frac{3333II}{3333IYI}$

Line 7y x 1y 4

 F₁
 $\frac{Y2}{Y3} * Y Y^{II}$

Suppurative Pleuritis
 Pericarditis, Myocarditis (Wounds) Pseudoleukemia
 F₁ Red ♀ 102374 *F₁ Bl ♂ 110567
 Line 7 Gen.C Age 1yr 7mo 1day Line 1 C Age 2yr 2mo 6days

F ₁	14 Daughters	F ₁	9 Sons
Red ♀ 103083	Pulmonary Infection Age 1yr	*Alb ♂ 100737	Pseudoleukemia Age 1yr 23days
*Alb ♀ 103541	Lymphatic Leukemia Age 1yr 4mo 2days	Alb ♂ 103432	Chronic Nephritis Age 1yr 1mo 15days
*Alb ♀ 109110	Pseudoleukemia Age 1yr 7mo 15days	Red ♂ 104466	Chronic Nephritis Hemorrhagic Appendicitis Colitis Age 1yr 3mo 21days
Alb ♀ 109798	Chronic Nephritis Age 1yr 8mo 10days	*Bl ♂ 108717	Sp cell Sarcoma Subcut invading Arm Age 1yr 8mo 3days
Red ♀ 110619	Pulmonary Infection Age 2yr	*Red ♂ 110802	Multiple Carcinomas Lungs Age 2yr 7days
*Alb ♀ 111836	Spindle cell FibroSarcoma of Abdominal Wall Age 2yr 1mo 24days	Bl ♂ 110872	Chronic Nephritis Age 1yr 9mo 27days
*Alb ♀ 111841	Spindle cell Sarcoma of Abdominal Wall Metastases in Lymph Node Age 2yr 16days	*Alb ♂ 110897	Pseudoleukemia Age 1yr 8mo 23days
*Blue ♀ 111885	Subcut Spindle cell FibroSarcoma Age 1yr 10mo 7days	Red ♂ 108238	Acute Nephritis (Wounds) Age 1yr 6mo 10days
Red ♀ 106347	Pneumonia, Abscess in Inguinal Muscl Age 1yr 15days	Alb ♂ Lost	At age 3mo 1day
*Red ♀ 114327	Carcinoma Lungs, Metas. & Hemorrhage in Lungs Age 1yr 11mo 7days		
*Red ♀ 113767	2 Carcinomas Lungs Fatal Hemorrhage in Lung Age 1yr 10mo 12days		
Bl ♀ 99417	Unknown Infection Age 6mo 10days		
Alb ♀ 116149	Intestinal Infection Age 2yr 4mo 23days		
*Bl ♀ 115389	Sp cell Sarcoma Subcut Carcinoma Mammary Gland Age 2yr 26da.		

	NC	C
Prob for 23 - 2	875	20125
(of test age) Prob for 17 - 2	125	14875
Findings for 17 -	5	12
♀ -	3	8
♂ -	2	4

Chart 107 But note that when the same F₁ ♀ 102374 was hybridized with ♂ 110567 that came from Line 1 which carried breast cancer breast carcinoma occurred in the first hybrid generation in ♀ 115389 Breast carcinoma persisted in this hybrid Line 7y x 1y⁴ throughout its entire course The male was here responsible for the occurrence of breast cancer There is a shortage of only 28 malignancies

CHART 89

LINE 7, Br I F₃

Parents F₂ ♀ 2 sarc body-wall
mult sarc abd. organs
21 mo 8 da (107201)

Malignancy
D₁D₂D₃
d₁d₂d₃

Localization
M L O b S
m l o b s

F ♂ carc lung 23 mo 19 da
(108430)

d₁D₂D₃
d₁d₂d₃

M I O B S
M l o b s

No offspring 10 7 ♀ 3 ♂ (3 NC ♂ dead under age)
No in findings 7 7 ♀ (4 lived from 19-27 mo)

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (3 13)

For 10

NC C
1 875 8 125

For 7

1 311 5 681

Findings for 7

1 6

Prob

NC

Carc

Sarc

Leuks

C L

C-S

S-L

C-S-L

For 10

1 875

1 875

1 875

625

625

1 875

625

625

For 7

1 311

1 311

1 311

437

437

1 311

437

437

Findings for 7

1

0

3

2

0

0

0

1

Localization of malignancy (assortment of malignancy and localization factors) 2 recessives (1 for malignancy 1 for localization)

	PROB 10 7 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	2 5	1	0
ovary (7 1)	875	5	1
bw (3 1)	2 5	1 5	2
subcut (7 1)	1 25	75	2
	<hr/> 7 125	<hr/> 3 75	<hr/> 5

Three recessives (1 for malignancy 1 for localization)

lung ovary (15 1)	4375	25	0
bw sub (15 1)	625	25	0
	<hr/> 1 0625	<hr/> 5	

Four recessives (2 for malignancy 2 for localization)

lung-bw (15 1)	625	25	0
lung-sub (31 1)	3125	125	0
ov-bw (31 1)	2188	125	0
ov-sub (63 1)	1094	0625	1
	<hr/> 1 2657	<hr/> 5625	<hr/> 1

Summary of malignancy (factors for malignancy considered alone) based on no of individuals

carc	5	2	1
sarc	5	3	4
leuks	2 5	1 75	3

Summary of localization (assortment of malignancy and localization factors) based on no of tumors

carc	3 375	1 5	1
sarc	3 75	2 25	4

Chart 89

 Strain $\frac{3333II}{3333I\gamma I}$

Line 7

 F₃ Br I

 Sp cell sarc of mesentery, intes,
ovaries, kidney, uterus, pancr,
liver, muscle, lymph nodes and

2 SpC Sarcomas of Body Wall

 Carcinoma Lung
Hemorrhage in Mediastinum

 *F₂ Red ♀ 107201

*Red ♂ 108430

 C₁ Age 1yr 9mo 8days

 C₁ Age 1yr 10mo 19days

 F₃

7 Daughters

 F₃

3 Sons

*Bl ♀	113448	Fatal Hemorrhage from Spindle cell Sarcoma Arm Ovarian Carcino, Pseudoleukem. Age 2yr 3mo 8days
*Red ♀	106326	Spindle cell Sarcoma Subcut. Suppurative Myocarditis Age 1yr 5mo 23 days
*Red ♀	111196	Pseudoleukemia, Intest Infect Age 1yr 8mo 20 days
Bl ♀	112637	Lung Adenoma Fatal Hemorrhage from Ruptured Abdominal Aorta Age 1yr 10mo 26 days
*Red ♀	109634	Pseudoleukemia from Thymus Lympho Sarcoma Age 1yr 5mo 10 days
*Red ♀	107790	Spindle cell Sarcoma Abdominal Wall invading Ovaries, Mesentery Diaphragm, and Intestinal Wall Age 1yr 3mo 2 days
*Bl ♀	110395	Osteoid Sarcoma Pelvic Wall invading Uterus & Pelv Bones Multiple Metastases Lungs Age 1yr 7mo 16 days

Red ♂	97457	Acute Nephritis (Wounds) Age 8mo 6 days
Red ♂	97599	Wounds Age 8mo 10 days
Alb ♂	99880	Chronic Nephritis Age 10mo 26 days

	NC	C	
Prob 10	—	1875	8 125
Prob 7	—	1311	5 681
Findings 7	—	1	6

Chart 89 (which continues Line 7) shows F₂ ♀ 107201 with multiple sarcomas, mated with ♂ 108430 with carcinoma of the lung. Note that there is sarcoma and carcinoma in the F₃ offspring but no breast carcinoma. The findings for malignancy are in exact accord with the probabilities for the theory.

CHART 93

LINE 7, Br II, F₄ A

Parents F₁ ♀ carc lung 25 mo 21 da
(gen leuks) (113770)

F₂ ♂ pseudoleuk 8 mo
(97060)

Malignancy	Localization
d ₁ D ₂ d ₃	M I O B S
d ₁ D ₂ d ₃	M I O b s
D ₁ D ₂ d ₃	M L O b S
d ₁ d ₂ d ₃	M I O b s
(suppression of sarc by dom allelomorphs)	

No offspring 8 5 ♀ 3 ♂ (2 NC ♂ dead under age)
No in findings 6 5 ♀ 1 ♂ (2 lived into late test age)

Distribution of malignancy (factors for malignancy considered alone)

Probabilities	NC	C
For 8	0	8
For 6	0	6
Findings for 6	0	6

Prob	NC	carc	leuks	carc-leuks
For 8	0	0	4	4
For 6	0	0	3	3
Findings for 6	0	1	5	0

(4 of the leuks died under the age for carc lung)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 8, 5 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
ovary	0	0	0
lung (3 1)	2	5	1
bw	0	0	0
sub	0	0	0
	<hr/> 2	<hr/> 5	<hr/> 1

No probabilities for 3 and 4 recessive assortments

Summary of malignancy factors (for malignancy considered alone) based on no of individuals

carc	4	1	1	
sarc	0	0	0	
leuks	8	6	5	
	<hr/> 12	<hr/> 7	<hr/> 6	Short 1

Summary of localization (assortment of malignancy and localization factors), based on no of tumors

carc	2	5	1	
sarc	0	0	0	
	<hr/> 2	<hr/> 5	<hr/> 1	Short 0

Chart 93

Strain $\frac{3333II}{3333I\gamma^1}$
 $\frac{\gamma 2}{\gamma 3} \star \gamma \gamma II$

Line 7
 F4 Br II
 A

$\star F_3$ Alb ♀ 113770 Carcinoma Lung, Senile Atrophy
 C Age 2yr 1mo 21days
 $\star B1$ ♂ 97060 Pseudoleukemia from Thymus Lympho Sarcoma
 C Age 8mo

F4		5 Daughters	F4	3 Sons
\star Alb ♀	97139	Thymus Lympho Sarcoma becoming Pseudoleukemia Age 4mo 11days	\star B1 ♂	100402 Thymus Lympho Sarcoma becoming Pseudoleukemia Age 7mo 25days
\star B1 ♀	99790	Thymus Lympho Sarcoma Ovarian Lympho Sarcoma becoming Pseudoleukemia Age 7mo 4days	Alb ♂	100584 Intestinal Infection Age 8mo
\star B1 ♀	113208	2 Carcinoma Lungs Age 1yr 11mo 6days	Alb ♂	101009 Pulmonary Infection Age 8mo 16days
\star B1 ♀	109112	Pseudoleukemia Age 1yr 5mo 10days		
\star Alb ♀	115862	Pneumonia Pseudoleukemia Age 2yr 3mo 10days		

	NC	C
Prob 8	0	8
(of test age) Prob 6	0	6
Findings 6	0	6

Chart 93 Here F_3 ♀ 113770 with carcinoma of the lung is mated with ♂ 97060, with pseudoleukemia. Here there are two different types of malignancy mated. Note that leukemic diseases and lung carcinoma occur in the offspring, but there is no breast carcinoma. The findings are in exact accord with the probabilities.

CHART 98

LINE 7 Br II F₄ F

Parents	F ₁ ♀ carc lung 24 mo 10 da (gen sarc) (114871)	Malignancy d ₁ d ₂ D ₁	Localization M l o b s
		d ₁ d ₁ d ₁	M l o b s
	*F ₂ ♂ benign adenomatous hyperplasia lung pneumonia 27 mo 1 da (116467)	D ₁ D ₂ D ₁	M l o b s
		d ₁ d ₁ d ₁	m l o b s

* Benign hyperplasia of the lung is not counted among the malignancies

No offspring	26	11 ♀	15 ♂	(3 NC ♀ 3 NC ♂ dead under age)
No in findings	20	8 ♀	12 ♂	(all 20 in late test age)

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (3 13)

	NC	C
For 26	4 875	21 125
For 20	3 75	16 25
Findings for 20	4	16
		♀ 1 7 ♂ 3 9

Prob	NC	Carc	Sarc	Leuks	C L	C-S	S-L	C-S-L
For 26	4 875	4 875	4 875	1 625	1 625	4 875	1 625	1 625
For 20	3 75	3 75	3 75	1 25	1 25	3 75	1 25	1 25
Findings for 20	4	8	5	1	1	1		

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 26 11 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	6 5	5	9
ovary (7 1)	1 375	1	2
bw (7 1)	3 25	2 5	3
sub (7 1)	3 25	2 5	3
	14 375	11	17
			(over-assortment of lung carc)

Three recessives (1 for malignancy 2 for localization)

lung ov (15 1)	6875	5	1
bw sub (31 1)	8125	625	1
	1 5	1 125	2

Four recessives (2 for malignancy, 2 for localization) carc sarc

lung bw (31 1)	8125	625	0
lung-sub (31 1)	8125	625	0
ov-bw (63 1)	1719	125	1
ov sub (63 1)	1719	125	0
	1 9688	1 5	1

Summary of malignancy (factors for malignancy considered alone) based on no of individuals

carc	13	10	10
sarc	13	10	6
sarc	6 5	2 5	2
leuks	32 5	23 5	18
			Short 4 5

Summary of localization (assortment of malignancy and localization factors), based on no of tumors

carc	7 875	6	11
sarc	6 5	5	6
	14 375	11	17
			Short 0

Line 7
F₄ Br II
F

CHART 98

3333 II
Strain 3333 Iy¹
Y²/Y³ *yy¹¹

*Bl ♀ 114871 Carcinoma Lung
Age 2 yr 10 da
Bl ♂ 116467 Mult Adenomas Lungs,
Pneumonia
Age 2 yr 3 mo 1 da

F ₄	11 Daughters	F ₄	15 Sons
*Alb ♀ 116652	Ovarian Adenoma, Lung Aden., 2 Sp cell Sarcomas Abd Wall, Perirenal and Lung Metas Age 2 yr 9 da	*Bl ♂ 116775	Carcinoma Lung Age 2 yr 15 da
*Bl ♀ 119320	Sp cell Sarc Pelvic Wall and left Hind Leg Age 2 yr 4 mo 22 da	*Bl ♂ 118417	Sp cell Sarc Seminal Ves Lung Adenoma Age 2 yr 3 mo 6
*Alb ♀ 119455	Ovarian Adenoma, Ca Lung Age 2 yr 4 mo 27 da	*Bl ♂ 119221	Carcinoma Lung Age 2 yr 5 mo 12 da
Bl ♀ 110826	Intest Infection, Peritonitis Age 3 mo 1 da	Bl ♂ 119614	Chronic Nephritis Age 1 yr 4 mo 22 da
Alb ♀ 117790 (3) (9)	Intestinal Infection, Jaundice Age 1 yr 1 mo 26 da	*Bl ♂ 125399 (1)	Carcinoma of Lung Age 2 yr 1 mo 20 da
Bl ♀ 117820 (1)	Intestinal Infection, Jaundice Age 1 yr 3 mo 12 da	*Bl ♂ 125375	Carcinoma of Lung Age 2 yr 2 mo 27 da
Alb ♀ 124812 (2)	Intestinal Infection Age 2 yr 2 mo 11 da	Bl ♂ 111813	Intestinal Infection Age 1 yr 1 mo 14 da
*Alb ♀ 123164 (3) (3)	Carcinoma of Lung Age 1 yr 7 mo 18 da	Alb ♂ 122769 (2)	Rupture Thoracic Aorta Age 1 yr 9 mo 24 da
*Bl ♀ 121694 (5)	Subcut Sp cell Sarcoma Age 1 yr 8 mo 9 da	Alb ♂ 120244 (2) (5)	Acute Neph, Myocarditis Age 1 yr 3 mo 14 da
*Bl ♀ 123095 (6)	Ca Lung, Lymph Hyperplasia Age 1 yr 10 mo 10 da	*Bl ♂ 127640 (4)	Early Pseudo Leukemia Age 2 yr 5 mo 2 da
*Bl ♀ 124368 (7)	Carcinoma of Lung Age 2 yr 23 da	Bl ♂ 124192 (6)	Intestinal Infection Age 1 yr 11 mo 17 da
		*Alb ♂ 129790 (7)	Sp cell Sarc Thoracic Wall Age 2 yr 9 mo 16 da
		Bl ♂ 123746	Suppurative Wounds Age 1 yr 10 mo 21 da
		*Bl ♂ 126312 (9)	Ca Lung and Base of Teeth Age 2 yr 4 mo 7 da
		*Bl ♂ 126153	Sp cell Sarc of Face and Jaw Age 2 yr 1 mo 24 da

NC C
Prob for 26 - 4 875 21 125
(of test age) Prob for 20 - 3 75 16 25
Findings for 20 - 4 16
♀ - 1 7
♂ - 3 9

Chart 98 Here F₂ ♀ 114871 with carcinoma of the lung is mated with ♂ 116467 with multiple benign adenomas of the lung. The results show that benign lung adenomas did not show the genetic behavior of a malignancy as such a cross should have given 100 per cent lung malignancy. The findings here are in exact accord with the probabilities of the theory, namely 4 NC 16 C. There is no breast carcinoma.

CHART 101

LINE 7, Br II F, F₁ (3) II

Parents F₁ ♀ adenoma ovary
2½ mo 22 da (130764)

F₁ ♂ subcut sarc (128289)
15 mo 3 da

Malignancy

d₁D₁D₁
d₁d₁d₁

Localization

M L o b s
M l o b s

D₁d₁D₁
d₁d₁d₁

M l O B s
M l o b s

No offspring 18 9 ♀ 9 ♂ (3 NC ♂ dead under age)
No in findings 15 9 ♀ 6 ♂ (13 in late test age)

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (3 13)

NC

C

For 18

3 375

14 625

For 15

2 8125

12 1875

Findings for 15

4

11

♀ 3 7
6 2 4

Prob

NC

Carc

Sarc

Leuks

C-L

C-S

S-L

C-S-L

For 18

3 375

3 375

3 375

1 125

1 125

3 375

1 125

1 125

For 15

2 8125

2 8125

2 8125

9375

9375

2 8125

9375

9375

Findings for 15

4

6

3

0

0

1

1

0

(1 sarc prostate)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 18 9 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	4 5	3 25	6
ovary (3 1)	2 25	2 25	3
bw (3 1)	4 5	3 25	2
sub (3 1)	4 5	3 25	1
	<u>15 75</u>	<u>12</u>	<u>12</u>
			(over assortment carc lung)

Three recessives (1 for malignancy 2 for localization)

lung-ov (7 1)	1 125	1 125	0
bw-sub (7 1)	2 25	1 625	1
	<u>3 375</u>	<u>2 75</u>	<u>1</u>

Four recessives (2 for malignancy 2 for localization)

lung-bw (15 1)	1 125	8125	1
lung sub (15 1)	1 125	8125	1
ov-bw (15 1)	5625	5625	0
ov sub (15 1)	5625	5625	0
	<u>3 375</u>	<u>2 75</u>	<u>2</u>

Summary of malignancy (factors for malignancy considered alone), based on no of individuals

carc	9	7 5	7
sarc	9	7 5	5
leuks	4 5	3 75	1
	<u>22 5</u>	<u>18 75</u>	<u>13</u>
			Short 5 75

Summary of localization (assortment of malignancy and localization factors), based on no of tumors

carc	6 75	5 5	7
sarc	9	6 5	5
	<u>15 75</u>	<u>12</u>	<u>12</u>
			Short 0

Line 7		Chart 101		Strain $\frac{3333 \text{ II}}{3333 \text{ IY}^1}$	
F ₆ Br II		F ₅ ★ Alb ♀	Adenoma Ovary	Subcut Sarc, Pneumonia	
F ₆ ③ II		C 130764	★ Alb ♂ 126269		
		C Age 2yr 22da.	C Age 1yr 3mo. 3da		
F ₆		9 Daughters		F ₆	
				10 Sons	
★ Alb ♀	131017	Adenoma Ovary		Alb ♂	127694 Aden. Lung, Pleuritis, Pericarditis
Alb ♀	131323	Pneumonia		Alb ♂	128310 Chronic Neph, Subcut Abscess
★ Alb ♀	131335	Sp. cell Sarc. Abd Wall, Hem. Ovaries		★ Alb ♂	129121 Carc. Lung, Intest. Infec.
★ Alb ♀	132521	Carcinoma Lung, Hem. Ovaries		Alb ♂	129210 Intestinal Infection
Alb ♀	133135	Hem. Ovaries Intest. Infec., Jaundice		★ Alb ♂	129325 2 Carcinomas Lung
★ Alb ♀	133333	Sarc. of Abd & Thor Walls & Diaphr.		Alb ♂	128924 Adenoma Lungs
★ Alb ♀	133391	2 Subcut Sarc. Thoracic Wall		★ Alb ♂	130511 Sp. cell Sarc. Prostate involving Rect.
★ Alb ♀	133744	Carcinoma Lung		★ Alb ♂	131432 Carc. Lungs, Metas. Lungs
★ Alb ♀	133861	Sarc. left Abd Wall & both Hind Legs		Alb ♂	133219 Pulmonary Infection
		Hem. Ovary, Carcinoma Lung			
		Age 1yr 11mo. 27da.			
		NC	C	NC : C	
(of test age)		Prob. for 18 - 3 375	14 625	♀ 2 7	
Findings for 15		2 8125	12 1875	♂ 2 4	
		4	11		

Chart 101 Here F₅ ♀ 130764, with malignant adenoma of the ovary, is mated with ♂ 126269, with subcutaneous sarcoma. Sarcomas, adenomas, and leukemic diseases occur in the offspring, but there is no breast carcinoma. This also is a cross between two types of malignancy and the fact that we do not get 100 per cent of malignancy demonstrates that there is one unit recessive factor for carcinoma (or adenoma) and another unit recessive factor for sarcoma. The results show a shortage of only 1/18 malignancies for perfect accord with the theory.

CHART 103

LINE 7, Br II F, F₁ (4)Parents F₁ ♀ carc lung 19 mo 18 da
(123164)

Malignancy

d₁D₂D₃d₁d₁d₁

Localization

M l o b s

M l o h s

F₁ ♂ pseudoleuk 29 mo 2 da
(127640)D₁D₂d₁d₁d d₁

M l o b s

M l o h s

No offspring 14 8 ♀ 6 ♂ (3 NC ♂ dead under age)

No in findings 11 8 ♀ 3 ♂ (8 in late test age) 6 ♀ 2 ♂

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (3 13)

NC

C

For 14

2 625

11 375

For 11

2 0625

8 9375

Findings for 11

5

6

♀ 3 5

♂ 2 1

Prob

NC

Carc

Sarc

Leuks

C-L

C S

S L

C-S L

For 14

2 625

875

875

2 625

2 625

875

2 625

875

For 11

2 0625

6875

6875

2 0625

2 0625

6875

2 0625

6875

Findings for 11

5

1

1

3

0

1

(2 leuks died under age for carc)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 14 8 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	3 5	3	1
ovary (3 1)	2	1 5	1
bw (3 1)	3 5	2	2
sub (7 1)	1 75	1	1
	<hr/> 10 75	<hr/> 6 5	<hr/> 5

Three recessives (1 for malignancy 2 for localization)

lung-ov (7 1)	1	75	0
bw sub (7 1)	1 75	1	1
	<hr/> 2 75	<hr/> 1 75	<hr/> 1

Four recessives (2 for malignancy 2 for localization)

lung-bw (15 1)	875	5	0
lung sub (31 1)	4375	25	0
ov-bw (15 1)	5	375	1
ov-sub (31 1)	25	1875	1
	<hr/> 2 0625	<hr/> 1 3125	<hr/> 2

Summary of malignancy (factors for malignancy considered alone), based on no of individuals.

carc	7	4	2
sarc	3 5	2	2
leuks	7	4	3
	<hr/> 17 5	<hr/> 10	<hr/> 7

Short 3

Summary of localization (assortment of malignancy and localization factors), based on no of tumors

carc	5 5	3 5	3
sarc	5 25	3	3
	<hr/> 10 75	<hr/> 6 5	<hr/> 5

Short 1 5

Line 7		Chart 103		Strain $\frac{3333 \text{ II}}{3333 \text{ Iy}^1}$ $\frac{Y^2}{Y^3} \star YY^{11}$	
F ₅ Br II		F ₄ Alb ♀		Pulmonary Infec Early Pseudoleuk	
F ₄		123164		★ Bl ♂ 127640	
		Age 1yr 7mo 18da.		C Age 2yr 5mo 2da	
F ₅	8 Daughters		F ₅	6 Sons	
★ Alb ♀	127620	Leukemia Age 1yr 2mo 4da	Bl ♂	127315	Abscess Lung Supp Wounds, Hyperplastic Spleen Age 1yr 2mo 5da
★ Alb ♀	129296	Pseudoleukemia Age 1yr 5mo 23da	Alb ♂	127325	Wounds, Acute Nephritis Age 1yr 3mo 28da
★ Alb ♀	129926	Reticulum Cell Sarcoma Liver Age 1yr 7mo 22da	★ Bl ♂	127990	Carcinoma Lung Age 1yr 5mo 10da
Alb ♀	130189	Intestinal Infection Acute Dilatation of Stomach Age 1yr 8mo 10da	Alb ♂	128841	Pulmonary Infection Intestinal Infection Age 1yr 5mo 14da
★ Alb ♀	130538	Fibro Sarc Abd Wall, Pneumonia Age 1yr 9mo 4da	Bl ♂	129907	Acute Neph, Urinary Reten Age 1yr 7mo 21da
Bl ♀	132289	Pulmonary Infection Age 2yr 3da	Alb ♂	123241	Intestinal Infection Age 2mo 14da
★ Alb ♀	133428	Sarc Pelvic Wall and Hind Leg Intra Abd. Sarc., Adenoma Ovary Age 2yr 2mo 5da			
Bl ♀ I	131698	Chronic Nephritis Age 1yr 8mo 18da			
NC : C					
Prob for 14-2 625 11 375					
(of test age) Prob for 11 2 0625 8 9375					
Findings for 11 5 . 6					
♂ 3 5					
♀ 2 1					

Chart 103 Here is another cross between two different types of malignancy F₄ ♀ 123164, with carcinoma of the lung, mated with ♂ 127640, with pseudoleukemia. Here again different recessive genes control carcinoma and pseudoleukemia respectively since we do not get 100 per cent malignancy from such a cross. The findings are only 29 malignancies short for the theory. Leukemias carcinoma, and sarcoma occur as expected, but there is no breast carcinoma.

CHART 110

LINE 7, Br II $\frac{E}{F}$ F₆ IParents F₆ ♀ mult osteo-sarc body-wall
27 mo 3 da (125001)

Malignancy

D₁d₂D₁d₁d₂d₂

Localization

M L o b S

M l o b S

F₆ ♂ carc lung 32 mo 18 da
(127477)d₁D₂D₂d₁d₂d₂

M l o B S

M l o b s

No offspring 28 18 ♀ 10 ♂ (4 ♀ 1 ♂ dead under age)

No in findings 23 14 ♀ 9 ♂ (21 in late test age) 12 ♀ 9 ♂

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (3 13)

NC

C

For 28

5 25

22 75

For 23

4 314

18 694

Findings 23

4

19

♀ 2 12

♂ 2 7

Prob

NC

Carc

Sarc

Leuks

C-L

C-S

S-L

C-S-L

For 28

5 25

5 25

5 25

1 75

1 75

5 25

1 75

1 75

For 23

4 314

4 314

4 314

1 438

1 438

4 314

1 438

1 438

Findings 23

4

11

2

1

1

4

1

4

(1 carc jaw)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB	28, 18 ♀	PROB	TEST AGE	FINDINGS
m gl		0		0	0
lung (3 1)		7		5 25	6
ovary (1 1)		9		6	9
bw (3 1)		7		5 25	6
sub		0		0	0
		<hr/> 23		<hr/> 16 5	<hr/> 21

Three recessives (1 for malignancy 2 for localization)

lung-ov (3 1)

4 5

3

0

Four recessives (2 for malignancy 2 for localization) carc sarc.

lung-bw (15 1)

1 75

1 313

0

ov bw (7 1)*

2 25

1 5

4

4

2 813

4

* If this probability is based on the entire fraternity there is no over assortment

Summary of malignancy (factors for malignancy considered alone), based on no of individuals

carc	14	10 5	16
sarc	14	10 5	6
leuks	7	5 25	2
	<hr/> 35	<hr/> 26 25	<hr/> 24

(over-assortment of carc)

Short 2 25

Summary of localization (assortment of malignancy and localization factors) based on no of tumors

carc	18	11 25	15
sarc	7	5 25	6
	<hr/> 23	<hr/> 16 5	<hr/> 21

Short 0

Line 7 F ₆ Br II		E F ¹	Chart 110		Strain 3333 II Y ² / ₃ ★ YY ¹¹	
F ₅ ★ Bl ♀ 125001		Mult Osteo Sarcomas Dorsal & Vent Thor Walls, Ribs & Pleura		Carc Lungs ★ Bl ♂ 127477		
C Age 2yr 3mo 3da				C Age 2yr 8mo 18da		
F ₆ 17 Daughters				F ₆ 10 Sons		
★ Bl ♀ 118790	Thymus Lymphosarc becoming Pseudoleuk	Alb ♂ 123908	Chronic Nephritis			
	Age 9mo 13da		Age 1yr 2mo 14da.			
Bl ♀ 124582	Acute Neph., Urinary Reten., Hyp Heart	★ Bl ♂ 126699	Carcinoma of Lung			
	Age 1yr 4mo 18da		Age 1yr 11mo 16da			
Bl ♀ 125125	Pneumonia, Hem Ovaries	★ Bl ♂ 126272	Angio Sarc Thoracic Wall, Fatal Hem			
	Age 1yr 4mo 22da.		Age 1yr 10mo 24da			
★ Bl ♀ 125765	Abscess Lungs, Adenom Uterus & Ovary	★ Bl ♂ 127916	Sq cell Ca. Base of Teeth invading Bone			
	Age 1yr 7mo 4da.		Age 2yr 2mo 11da.			
★ Alb ♀ 126720	Carcinoma of Lung	Bl ♂ 127658	Acute Nephritis, Urinary Retention			
	Age 1yr 5mo 28da		Age 1yr 9mo 18da.			
Bl ♀ 122212	Pulmonary Infection	★ Bl ♂ 128395	2 Carcinomas Lung			
	Age 10mo 20da		Age 1yr 11mo 6da			
★ Bl ♀ 127760	Bilateral Adenomas of Ovaries	Bl ♂ 130591	Cort cell Adenoma Adrenal, Chr Neph			
	Age 1yr 11mo 16da		Age 2yr 3mo 28da			
★ Bl ♀ 127352	Adenoma Ovary, Chronic Nephritis	★ Bl ♂ 130847	Multiple Carcinomas Lungs			
	Age 1yr 10mo 20da		Age 2yr 2mo 28da			
★ Bl ♀ 128403	R.C. Sarc Abd Wall, Adenoma Ovary	★ Bl ♂ 131241	Ca Lung Metas Lungs, Adenom Lung			
	Age 2yr 21da.		Age 2yr 7mo 1da			
★ Bl ♀ 128405	Adenoma & Hemorrhage Ovary	★ Bl ♂ 132614	Carcinomas Lungs			
	Age 2yr 21da		Age 2yr 5mo 23da			
Bl ♀ 128491	Supp. Nephritis, General Infection					
	Age 1yr 9mo 2da					
★ Bl ♀ 129691	Sp.cell Sarc Pelvic Wall, Aden. Ovary, Pneum					
	Age 2yr 6mo. 3da					
★ Bl ♀ 129742	Sp.cell Sarc Abd Wall, Adenoma Ovary					
	Age 2yr 6mo. 6da					
★ Alb ♀ 130780	Sp.cell Sarc Rt Abd Wall and Hind Leg					
	2 Sp.cell Sarc Inner Aspect Thoracic Wall					
	Age 2 yr 2mo 22da					
Bl ♀ 124584	Hemorrhage Ovaries					
	Age 1yr 4mo 18da.					
★ Bl ♀ 127162	Endothel Sarc Liver, Spleen, Neck Nodes					
	Bilateral Adenomas Ovaries					
	Age 1yr 10mo 7da.					
		★ Alb ♀ 127487	2 Sp.cell Sarc Abd. Wall, Mult Lung			
			Metas, Bilat Adenomas Ovaries			
			Age 2yr 1mo 14da			

Chart 110 Again a cross is made between two different types of malignancy, F₅ ♀, with multiple sarcomas in multiple sites and ♂ 127477 with lung carcinoma. Again the expectation is not 100 per cent malignancy but instead a ratio of 4 NC 19 C. The findings are in exact accord with the expected ratio Sarcomas, carcinomas and leukemic diseases occur in the offspring, but again there is no breast carcinoma

CHART 117

E
LINE 7, Br II F, F₂ VII

	Malignancy	Localization
Parents F ₂ ♀ int inf 17 mo 21 da. (123152)	D ₁ D ₂ D ₃ d ₁ d ₂ d ₃	M L o b S m l o b s
F ₂ ♂ multiple carc lungs 33 mo 3 da (130401)	d ₁ D ₂ D ₃ d ₁ d ₂ d ₃	M l o b s M i o b s

No offspring 21 12 ♀ 9 ♂ (3 NC ♂ dead under age)
No in findings 18 12 ♀ 6 ♂ (17 in late test age)

Distribution of malignancy (factors for malignancy considered alone)

Probabilities (9 23)

	NC	C
For 21	5 9067	15 0849
For 18	5 0625	12 9375
Findings for 18	6	12 ♀ 3 9 ♂ 3 3

Prob	NC	Carc	Sarc	Leuks	C L	-C-S	S-L	C-S-L
For 21	5 9067	5 9067	1 9689	1 9689	1 9689	1 9689	6563	6563
For 18	5 0625	5 0625	1 6875	1 6875	1 6875	1 6875	5625	5625
Findings for 18	6	6	2	1	1	1	0	1

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy for localization)

	PROB 21 12 ♀	PROB TEST AGE	FINDINGS
m gl	0	0	0
lung (3 1)	5 25	4 25	4
ovary (1 1)	6	6	6
bw (3 1)	5 25	4 25	4
sub (7 1)	2 625	2 125	2
	19 125	16 625	16

Three recessives (1 for malignancy 2 for localization)

lung-ov (3 1)	3	2 75	1
bw-sub (7 1)	2 625	2 125	2
	5 625	4 875	3

Four recessives (2 for malignancy 2 for localization)

lung-bw (15 1)	1 313	1 063	0
lung-sub (31 1)	6563	5313	0
ov-bw (7 1)	1 5	1 375	2
ov sub (15 1)	75	6875	1
	4 2193	3 6568	3

Summary of malignancy (factors for malignancy considered alone) based on no of individuals.

carc	10 5	9	9
sarc	5 25	4 5	4
leuks	5 25	4 5	3
	21	18	16 Short 2

Summary of localization (assortment of malignancy and localization factors) based on no of tumors.

carc	11 25	10 25	10
sarc	7 875	6 375	6
	19 125	16 625	16 Short 025

Line 7		Chart 117		Strain 33331Y ¹	
F ₆ Br II		F ₅ Bl ♀	Intest Infection	Mult. Ca. Lung	3333 II
E VII		Het NC	123152	*Blb 130401	Y ² /Y ³ *YY ¹¹
F VII			Age 1yr 5mo	Carc	Age 2yr 9mo 3da
F ₆	12 Daughters		F ₆	6 Sons	
*Bl ♀	123364	Aden Ovary with Fatal Hem	Bl ♀	127090	Intestinal Infection
		Age 1yr 2mo 21da			Age 1yr 8mo 17da
Bl ♀	126395	Intest Infection, Jaundice	Bl ♀	127459	Supp Wounds, Supp Myocard
		Age 1yr 7mo 3da			Age 1yr 7mo 10da
*Bl ♀	126674	Ca. Lung, Metas., Bilat Aden Ovaries	*Bl ♀	128110	Carcinoma Lung
		Age 1yr 9mo 17da			Age 1yr 9mo 22da
*Bl ♀	126802	Sp. cell Sarc Abd Wall, Intra Abd Exten	*Bl ♀	130212	Pseudo Leukemia
		Age 1yr 9mo 28da			Age 2yr 1mo 16da
*Bl ♀	127307	Carcinoma Lung	Alb ♀	130794	Appendicitis, Colitis
		Age 1yr 11mo 3da			Age 2yr 3mo 14da
*Bl ♀	127490	Lymphosarc Stom, Pancreas, Kidneys	*Alb ♀	133475	Ca. Lung, Cyst Aden. Subcut.
		Adenoma Ovary			Age 2yr 8mo 2da
		Age 1yr 11mo 11da			
*Bl ♀	127854	Aden. Ovary with Fatal Hemorrhage	NC : C Prob for 21 - 5 9067 - 15 0949 (of test age) Prob for 18 - 5 0625 - 12 9375 Findings for 18 - 6 12 ♀ - 3 9 ♂ - 3 3		
		Age 1yr 8mo 13da			
*Alb ♀	128505	Sp. cell Sarc Thor & Abd. Walls & 2 Subcut., Bilat Aden Ovaries, Pseudoleukemia			
		Age 2yr 18da			
Bl ♀	129707	Intestinal Infection			
		Age 2yr 10da			
*Bl ♀	129716	Sp. cell Sarc Thor Wall and Arm Adenoma Lung, Hem. Ovary			
		Age 2yr 2mo 4da			
Alb ♀	130364	Intestinal Infection	*Alb ♀	130012	Sp. cell Sarc. Thor & Abd Walls
		Age 2yr 3mo 19da			Aden. Ovary, Pneumonia
					Age 2yr 3mo 23da

Chart 117 Here heterozygous non-cancer ♀ 123152 (her father was genetically carcinomatous) is mated with ♂ 130401 with multiple lung carcinomas Sarcoma, carcinoma and leukemic disease occur but there is no breast carcinoma

The findings are in exact accord with the expectation for the theory Throughout these charts there is no evidence of an extra-chromosomal factor for breast cancer which was ruled out in the first generation by the dominant allelomorphs for localization in the breast carried in by the ♂ (shown in the first chart here presented)

These charts show the necessity for considering not only a malignancy factor but also a localization factor The small shortage of malignancy when malignancy factors only are considered is eliminated when the assortment of localization factors with malignancy factors is considered There is thus no shortage whatever of cancer occurrence for the entire Line 7 of 650 mice

TOTALS LINE 7, F₁₋₆

Parents	par ♀	care m gl 14 mo 11 da. (90501)	Malignancy factors d ₁ D ₂ D ₃ d ₁ D ₂ D ₃		Localization factors m L O B S m l o B s	
	par ♂	pneumonia 10 mo 27 da (86725)	D ₁ D ₂ D ₃ d ₁ d ₂ d ₃		M l O b S M l O b S	
No of mice		650 (344 ♀ 306 ♂)	173 NC	dead under test age	42 ♀	131 ♂
No in findings		477 (302 ♀ 175 ♂)				
Average NC age		22 5 mo	♀ 22 5 mo	♂ 22 5 mo	range 17-30 mo	
Average C age		22 3 mo	♀ 21 6 mo	♂ 23 mo	range 4-33 mo	

Distribution of malignancy (factors for malignancy considered alone)

Probabilities of malignancy (factors for malignancy considered alone)									
Probabilities	NC		C						
For 650	151	8245	498	2235					
For 477	108	8741	370	1259					
Findings for 477	155		322		♀ 70	232			
					♂ 85	90			
Probabilities	NC		Carc	Sarc	Leuks	C-L	C S	S-L	C-S-L
For 650	151	8245	125 7617	103 1313	59 5665	55 6289	89 3185	34 5021	30 3145
For 477	108	8741	90 6881	77 4375	42 4372	40 6252	69 1253	26 125	23 6876
Findings for 477	155		129	74	39	11	55	5	8

(1 teratoma omitted)

The conspicuous failures are in the multiple type groups which require the assortment of 4 and 6 recessive factors (2 or 3 for malignancy and 2 or 3 for localization)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 650, 344 ♀	PROB TEST AGE	FINDINGS	SHORT
m gl (d ₁ m)	0	0	0	
lung (d ₁ l)	174 0625	124 0625	123	
ovary (d ₁ o)	96 125	81 875	95	
body-wall (d ₁ b)	144 125	103 5	106	
subcut (d ₁ s)	83 688	60 25	62	
	498 0005	369 6875	386	0
Three recessives (1 for malignancy 2 for localization)				
lung-ovary (d ₁ lo)	55 4688	48 0938	16	
bw-subcut (d ₁ bs)	48 5951	32 5626	31	
	104 0639	80 6564	47	33 6564

The most conspicuous failure in the assortment of any group was in lung-ovary (sex incidence)

Four recessives (2 for malignancy 2 for localization) carc-sarc.

lung-bw (d ₁ d ₁ b)	41 7837	31 1266	19	
lung sub (d ₁ d ₁ ls)	22 5018	16 8913	7	
ov-bw (d ₁ d ₁ ob)	28 8439	24 5781	39	
ov sub (d ₁ d ₁ os)	14 8987	13 1798	19	
	108 0281	85 7758	84	1 7758

The probabilities for ov bw and ov-sub are based on the number of females. If these probabilities were based on the entire group there would have been no over assortment

Summary of malignancy (malignancy factors considered alone)

	Based on no of individuals.	
carc (d ₁)	210 5	203
sarc (d ₂)	185 75	142
leuks (d ₃)	125 5	63
	736 5	521 75
		408
		113 75

This considerable shortage of tumors in mice living into test age indicates the presence of another genetic factor assorting with the malignancy factor. This second recessive character is the factor for localization

Summary of localization (assortment of malignancy and localization factors) Based on no of tumors.

carc (d ₁)	270 1875	205 9375	218
sarc (d ₂)	227 813	163 75	168
	498 0005	369 6875	386
			0

To summarize The strain from which the parent female came was a *low percentage malignancy strain*. Of the tumors carried, it was relatively high in carcinoma of the mammary gland, very high in leukemic disease. There was neither ovarian ade-

noma nor sarcoma frankly shown in the parent female strain

The strain from which the parent male came was a *high percentage malignancy strain*. Of the tumors carried, it was relatively low in mammary gland carcinoma

only one-third as high a percentage of leukemic disease as in the female strain, high in lung carcinoma, low in ovarian adenoma, and high in sarcoma

The resulting hybrid strain of 650 mice, was a *high percentage malignancy line*, high in lung carcinoma, very high in sarcoma, high in ovarian tumors, relatively low in leukemic disease (nearly identical in percentage with the male strain), and with no mammary gland carcinoma whatever throughout nine generations of individually tested mice. There was throughout the whole range of malignant types tested no evidence of an extra-chromosomal factor.

These charts and figures demonstrate beyond doubt that types and sites of malignancy are segregating out, and hence that the tendency to malignancy and to its localization is inheritable. The actual findings given from every type of cross made, and the theory presented explain the facts and ratios of these findings so exactly that there is no shortage whatever in the number of malignancies, which is in complete accord with the theory.

I call your attention to the page of totals for the entire Line 7, of which only a few fraternities could be charted in this paper.

The parent female 90501 and the parent male 86725 are given with their formulæ both for malignancy and for localization. There were 477 mice that lived into test age. The average age of non-cancer mice was 22.5 months, identical for females and males. The average age of cancer mice was 22.3 months, for females 21.6 months and for males 23 months. Note the long range of age incidence in malignancy, from 4 to 33 months, due to the very early occurrence of some cases of leukemic disease.

The probabilities for 477 mice were 106.87 NC 370.12 C, the findings were 155 NC 322 C. This shortage of 48 cancerous individuals (when malignancy factors alone are considered) shows the necessity for a localization factor also to explain the findings.

For the validation of the theory it is necessary that there should be carcinoma

with every possible combination of these forms of malignancy. Note that all of these combinations did occur.

The probabilities and findings for 477 were

	NC	Carc	Sarc	Leuks
Probabilities	106.8741	90.6881	77.4375	42.4372
Findings	155	129	74	39
	C-L	C-S	S-L	C-S-L
Probabilities	40.6252	69.1253	26.125	23.6876
Findings	11	55	5	8

This is very striking when one considers that the chance to get the six recessive combinations, carc-sarc-leuks, of which there were eight in Line 7, varied from a $7/1$ chance to a $255/1$ chance, according to the type of matings made.

Note that throughout this line of 650 mice there is no breast cancer although the parent female, 90501, actually had breast cancer. There is no indication here of any extra-chromosomal factor. Neither is there any basis for considering malignancy as a dominant, since if one considers malignancy alone without the localizing factors there is a shortage of 7.5 carcinomas, 43.75 sarcomas, and 62.5 leukemic diseases, or a total shortage of 113.75 tumors, even for a recessive.

Note that when malignancy alone was considered there was a shortage of 48 cancerous individuals, but when the assortment of malignancy factors with localization factors was the basis of the analysis, there was no shortage whatever and the findings were in perfect accord with the theory of one unit recessive for carcinoma, one unit recessive for sarcoma, one unit recessive for leukemic disease, and one unit recessive for each location of malignancy. This requires the assortment of all these factors, each with the others, when all of these factors are bred in, as was the case in Line 7 here presented.

It seems to me that, so far from completely homozygous material being necessary for the solution of the problem of

TOTALS LINE 7, F₁₋₆

Parents	par ♀	carc m gl 14 mo 11 da (90501)	Malignancy factors				Localization factors					
			d ₁ D ₂ D ₃ d ₁ D ₂ D ₃				m L O B S m l o b s					
	par ♂	pneumonia 10 mo 27 da (86725)	D ₁ D ₂ D ₃ d ₁ d ₂ d ₃				M l O b S M l O b S					
No of mice		650 (344 ♀ 306 ♂)	173 NC dead under test age 42 ♀ 131 ♂									
No in findings		477 (302 ♀ 175 ♂)										
Average NC age		22 5 mo ♀ 22 5 mo ♂	range 17-30 mo									
Average C age		22 3 mo ♀ 21 6 mo ♂	range 4-33 mo									
Distribution of malignancy (factors for malignancy considered alone)												
Probabilities		NC		C								
For 650		151 8245		498 2235								
For 477		106 8741		370 1259								
Findings for 477		155		322		♀ 70 232 ♂ 85 90						
Probabilities		NC		Carc		Sarc		Leuks	C L	C-S	S-L	C-S-L
For 650		151 8245		125 7617		103 1313		59 5665	55 6289	89 3185	34 5021	30 3145
For 477		106 8741		90 6881		77 4375		42 4372	40 6253	69 1253	26 125	23 6876
Findings for 477		155		129		74		39	11	55	5	8

The conspicuous failures are in the multiple type groups which require the assortment of 4 and 6 recessive factors (2 or 3 for malignancy and 2 or 3 for localization)

Localization of malignancy (assortment of malignancy and localization factors), 2 recessives (1 for malignancy 1 for localization)

	PROB 650, 344 ♀	PROB TEST AGE	FINDINGS	SHORT
m gl (d ₁ m)	0	0	0	
lung (d ₁ l)	174 0625	124 0625	123	
ovary (d ₁ o)	96 125	81 875	95	
body-wall (d ₁ b)	144 125	103 5	106	
subcut. (d ₁ s)	83 688	60 25	62	
	498 0005	369 6875	386	0
Three recessives (1 for malignancy 2 for localization)				
lung ovary (d ₁ lo)	55 4688	48 0938	16	
bw-subcut (d ₁ bs)	48 5951	32 5626	31	
	104 0639	80 6564	47	33 6564

The most conspicuous failure in the assortment of any group was in lung-ovary (sex incidence)

Four recessives (2 for malignancy 2 for localization)	carc	sarc
lung-bw (d ₁ d ₁ lb)	41 7837	31 1266
lung-sub (d ₁ d ₁ ls)	22 5018	16 8913
ov-bw (d ₁ d ₁ ob)	28 8439	24 5781
ov-sub (d ₁ d ₁ os)	14 8987	13 1798
	108 0281	85 7758
		84 1 7758

The probabilities for ov-bw and ov sub are based on the number of females. If these probabilities were based on the entire group there would have been no over-assortment

Summary of malignancy (malignancy factors considered alone)	Based on no of individuals.
carc (d ₁)	302 75
sarc (d ₂)	255 5
leuks (d ₃)	178 25
	736 5

This considerable shortage of tumors in mice living into test age, indicates the presence of another genetic factor assorting with the malignancy factor. This second recessive character is the factor for localization

Summary of localization (assortment of malignancy and localization factors)	Based on no of tumors.
carc (d ₁)	270 1875
sarc (d ₂)	227 813
	498 0005
	369 6875
	386 0

To summarize The strain from which the parent female came was a *low percentage malignancy strain*. Of the tumors carried, it was relatively high in carcinoma of the mammary gland, very high in leukemic disease. There was neither ovarian ade-

noma nor sarcoma frankly shown in the parent female strain

The strain from which the parent male came was a *high percentage malignancy strain*. Of the tumors carried, it was relatively low in mammary gland carcinoma

death in each member of any family with a very small margin of error. A study of human records, such as I am suggesting, would show the attending specialist, first, the probable type of diseases to be expected in a family, due to ancestry, second, the meaning of symptoms, sometimes fatally hard to ascribe to their cause, but which have been presented before in the family, third, the probable reaction to types of treatment, and fourth, the probable prognosis. These things I can predict in my mice from knowledge of the family records.

This pre-knowledge of probable diseases, reactions, and prognosis within a family would, I think, if it were universally at the command of practitioners, revolutionize medicine, since we should then not only know something about the disease and its treatment of choice, but we should also know something about the patient.

DISCUSSION OF SYMPOSIUM

DR FRANCIS CARTER WOOD (New York City) I am happy to discuss Dr Portmann's paper because I think it represents a great advance in our classification of malignant growths of the breast from a practical aspect—one which will lead to the collection of statistics which are of value.

Unless we proceed with such classifications as this and all workers publish their records co-ordinating their cases just as Dr Portmann suggests and as he has done himself, we will have the continuation of the sort of statements which you can hear from any group of surgeons. For instance, most of them say that x-ray has been proved to be of no value post-operatively, entirely disregarding the large volume of statistics which are available from Germany.

Our own American statistics in general have not been properly collected, the cases have not been properly co-ordinated, the x-ray has been of varying types, and unless we can get a standard not only in classification, as Dr Portmann suggests, but also a classification and standardization of

cases in which radiation is necessary, we will never have a type of information which will enable us to advise the individual patient as to what should be done.

I quite agree with him that the pathologic classifications are of small value because grouping and studies of the morphology of cells are of little value to the individual. They tell what a hundred patients will do but they do not tell what the individual will do.

We know, for instance—always have known, in fact—that the gelatinous type of carcinoma is less malignant in a general sense than the scirrhus type and yet we all see patients with carcinomas of the gelatinous type die with great ease despite microscopic analysis, which shows that the tumor should be cured by operation. On the other hand, we do know that these gelatinous types are not susceptible to radiation.

The classification of Dr Portmann, it seems to me, is the best of the lot. It should be adopted in some official way. The College of Surgeons, you know, is printing forms on which records are to be made so as to avoid loose history-taking and to see that all the facts are recorded, and I think we might well do the same thing with Dr Portmann's plan. It is unquestionably the best that has been published so far.

There are still debatable matters, which Dr Portmann himself raises. Shall we consider every case with small pig-skin area as inoperable? I don't agree that it is. Nor do I always agree that we should not operate upon an ulcerating carcinoma. If the case is to be palliated with the greatest effectiveness, it is sometimes necessary to remove a large ulcerating breast simply without opening the axilla, close the wound as quickly as possible, and then begin post-operative radiation. That may restore the patient to a condition in which she can go back to her normal activities for a year or two.

Such people almost inevitably die, but there is a palliative surgery which, if you

find the solution. For when the only form of malignancy in a stock is breast carcinoma, then malignancy occurs only in the breast and only in the epithelium, and these two factors for malignancy and for localization thus seem to be one factor, because they always occur together, and it is misleading. But with material of this sort, homogeneous in that only certain types and sites of malignancy ever occur, but heterogeneous in that it carries more than one type and site of malignancy, then these combinations do occur, which make it possible to explain the genetics of cancer. This material shows every possible combination of the unit character for each type of malignancy, with every other type of malignancy, and with every unit character for localization. It seems to show that malignant growth of each type differs in only one gene from non-malignant growth of that type, since the figures are accurate only for malignancy and localization as unit recessives. For malignancy and localization, as unit recessives, the figures are nearly perfect.

This material in its heterogeneous content of malignancy, parallels human material in cancer occurrence, and this theory which I have demonstrated is submitted as a probable explanation of the genetics of human cancer.

All geneticists actually working in cancer agree that there is a hereditary basis in malignant disease. Indeed, so finally is this accepted that much of modern cancer research is based upon this fact, and strains of mice of different cancer susceptibility are now known to be necessary for such studies. Many of the outstanding members of the medical profession, radiologists, surgeons, dermatologists, and internists do accept this fact of cancer susceptibility. It is time to do something about it.

This brings me to the practical aspect of this work. What shall we do? I have been telling that for over sixteen years, and Karl Pearson, of England, before me, repeatedly made the same plea—that is, the plea for human records. I am here to make that plea again and to remind you that the

necessity for human records is the same, irrespective of any details of a genetic theory, indeed, they would in time prove the correctness or the error of any genetic theory, and they would be the court of last appeal.

I have spoken to this body of men and women many times, and your reception of me and of my work has been most cordial, but you also have done nothing about it, while cancer, of which you handle thousands upon thousands of cases, has finally come to be in second place of all death causes.

Like the others, you perhaps think we can do nothing to breed out cancer. Before Pasteur's work was accepted, and before Florence Nightingale's work was done, nobody thought there was any such truth about infections which placed them within control, and everybody scoffed at aseptic wounds and hospitals. Now these things are commonplaces and have become routine procedures. I am willing to admit that any step actually to breed out cancer may lie far ahead, but the glory will be to those who actually do it. And when it is done, it also will be routine procedure. If specific types and sites of tumor can be ruled out of mouse families, they can be ruled out of human families. In Line 7, carcinoma of the mammary gland, though bred in by the parent female, was eliminated in the first generation and permanently eliminated from the lives of nine generations thereafter, involving in the main line and its hybrid derivatives over a thousand tested females.

We can make possible this future procedure by the simple method of taking adequate records now, and assembling them in a central bureau where they can be of service.

There is, moreover, a matter in which these records will be of immediate value, and in which you yourself can use them. They will be of immeasurable and immediate diagnostic value. In the laboratory where the ancestry and the immediate family of every mouse is on record, it is possible to predict the probable causes of

DR SKINNER (closing) I feel that it is far more important to search for new methods of early diagnosis than for new cures—new methods of interesting physicians in early diagnosis

Professional education upon facts that

have advanced beyond consumption rates is already with us and this lag—this cultural lag—this educational lag—of the gap of time between facts and their application must be shortened

possible for her to do so otherwise. It also relieves the patient of the expense of dressings and the offensive odor which comes from such an ulcerating surface.

There is still a question as to how long these individuals' lives are prolonged, but I have a feeling that removal of the infectious material prolongs the patient's life somewhat and that radiation will prevent an immediate return.

There is another point, and that is we must do everything to ensure that our pathologic diagnoses are good. The College of Surgeons has forced upon the country a scheme which hospitals are not prepared to meet—that they must have a pathologist. Pathologists are scarce—good ones very much so—and it is quite astonishing to consider the number of incorrect diagnoses which are going on in the country, made by pathologists who are not properly trained.

There is need also for the careful checking of some of our doubtful types of tumors by experts, not trusting finally to a local pathologist's diagnosis.

DR WRIGHT CLARKSON (Petersburg, Va.)
I want to express my appreciation for the privilege of discussing this Symposium, particularly the paper by Dr. Skinner, in which I am especially interested. I believe that Dr. Skinner is going to help us a great deal with his emphasis upon what may be done to reduce the cancer mortality rate at the present time.

We all realize the great value of the work which Dr. Slye and many other research workers have accomplished. I think we are going to understand this work more in the future and I believe that great good will be accomplished by the added knowledge.

But we must not feel that it is going to take centuries to reduce the cancer mortality rate, because with our present knowledge of the subject we know that it can be reduced in the near future perhaps as much as 50 per cent, and that is immediately necessary.

There are so many things that enter into the great problem of reducing this mor-

tality rate that it seems almost futile to attempt to discuss such a question in the period of a few minutes, but it is necessary, it seems, for radiologists to go home to day with one thing in mind, at least—let us all try to do no harm to these patients!

You know, sometimes I wonder whether the physicians—taken as a class with the sum total of our accomplishments, taking us all, general practitioners and specialists—are really reducing the cancer mortality or whether we are elevating it.

That is a strange statement, but day after day patients come to my office, incurable because they have been mistreated by physicians, not only by general practitioners who may have enucleated a tumor of the parotid gland and disseminated the disease, but also by surgeons who, without any pre-operative irradiation, have performed a biopsy and disseminated the malignancy, and even by radiologists who have inadequately treated malignancy so that it is radioresistant and incurable.

It seems to me, then, that we can at least determine that we will go home with the idea that we will not do cancer patients harm. If we are inadequately equipped to handle them, let us turn them over to some one who is specializing in this complicated field.

I do not believe there is any branch of medicine more complicated or in which intense specialization is more needed, and this paper of Dr. Skinner has brought forcefully to our attention the fact that we should go out into the rural sections, because these patients are not coming to us. The farmer is busy with his crops and he will go a few miles to a clinic, but he will not travel many miles to a metropolis. We can all go out and teach our fellow-practitioners in the rural sections near us more about cancer—teach them to recognize it in its early stages, teach them to handle properly the simpler lesions and to refer such cases as are more complicated to some cancer specialist or cancer clinic where they can be properly handled. This is a definite remedy for a pressing need.

exposure is sufficient, but occasionally it may be advisable to repeat the treatment a few days later. This is particularly true when the initial dose has been exceptionally small or when the area treated has not been wide enough.

Pyogenic Infections—Among the acute inflammatory conditions in which the therapeutic value of irradiation has been established are furuncle, carbuncle, abscess, cellulitis and phlegmon, onychia and paronychia, acute adenitis and erysipelas. Other forms of acute inflammation such as otitis and mastoiditis, pelvic infection, osteomyelitis, and gas-bacillus infection, also appear to be influenced favorably, but in connection with some of them the evidence is not yet absolutely conclusive.

In spite of the experimental observations of Schaefer (1), Motojima (2), and Lacassagne and Vinzent (3), and of the clinical testimony of Coyle (4), Dunham (5), Ross (6), Hodges (7), Heidenhain and Fried (8), Pordes (9), and many others, the method is not used as widely as it might be. Most of the authors mentioned agree that the majority of the patients derive prompt benefit. When irradiated early, during the stage of maximal leukocytic infiltration, many lesions do not suppurate, their evolution is arrested and they undergo spontaneous resolution. Therefore, the treatment is most effective when other methods of treatment are least effective, it is painless and does not interfere with the activities of the patient. Pain is often relieved in a few hours, but sometimes the relief of pain may be preceded by exacerbation for a brief period. Hot or other dressings are often unnecessary, or the period during which they must be applied is shortened. Treatment after suppuration has set in tends to hasten the suppurative process, the duration of which may thus be diminished more or less. Hence, the patients should be kept under close observation so that, if necessary, the surgeon may provide adequate drainage at the proper time. But acute pyogenic inflammations do not always respond so favorably, in a minor

proportion of cases the inflammation yields little or not at all.

Pneumonia—As early as 1905 and 1906, Musser and Edsall (10), and Edsall and Pemberton (11) were the first to observe and to report the strikingly favorable influence of a small dose of roentgen rays in four cases of delayed resolution of lobar pneumonia. Every other therapeutic measure having failed to improve the pulmonary condition of the patients, roentgen irradiation was tried as a last resort. Within twenty-four hours after exposure, resolution of the pneumonic exudate set in, proceeded rapidly, and the patients recovered. These observations were subsequently confirmed by Qumby and Qumby (12), Krost (13), and Torrey (14). In fact, the Qumbys were so impressed by the rapid influence of irradiation in ten cases that they were impelled to testify that "no pathologic process in the body responds quicker to an x-ray exposure than the non-resolution following pneumonia." Since then, Heidenhain and Fried (8), Holzknecht (15), Merritt and McPeak (16), and others have observed an equally favorable action of roentgen rays on post-operative pneumonia as well as on pneumonia unrelated to surgical intervention, in a large percentage of cases in which the treatment was employed. Naturally, the best results are to be obtained from early treatment. As pointed out by Musser and Edsall (10), irradiation cannot be expected to have much effect once the pneumonic inflammation has become organized or when the treatment is given shortly before impending death.

Parotitis—Every surgeon is aware of the sinister character of that form of acute parotitis which arises as a complication of certain operations, especially on the large intestine, and of the high mortality associated with it. The first record of the favorable effect of irradiation on this disease appears to have been made by Heidenhain (17), who found that the inflammation reacted much as do other acute inflammatory processes. Rankin and Palmer (18) found that a moderate dose of

THE ACTION OF ROENTGEN RAYS OR RADIUM ON INFLAMMATORY PROCESSES¹

By ARTHUR U. DESJARDINS, M.D., *Rochester, Minnesota*

Section on Therapeutic Radiology, The Mayo Clinic

WHENEVER treatment with roentgen rays or radium is mentioned, the idea that rises in the average mind is that the speaker or writer must refer to malignant tumors. Many physicians are not aware of the favorable influence of these agents on various forms of acute or chronic inflammation. And yet the therapeutic value of irradiation in inflammations has been so thoroughly substantiated and the testimony is so generally favorable that one wonders why the method is not used more than it is. Perhaps the very multiplicity of lesions for which radiotherapy has been claimed to be effective has led to a natural skepticism. Also, the multiplicity of explanations which have been advanced to account for the influence of roentgen rays or radium on inflammatory conditions has probably led many physicians to discredit the evidence or to ascribe it either to enthusiasm or to psychic factors. Indeed, without a satisfactory and convincing explanation, it would be difficult to believe that the same agent could be therapeutically effective against so many different forms of inflammation in different parts of the body. And yet the reason appears to be simple and rests on sound and abundant experimental evidence.

Others who have heard or read of the therapeutic possibilities of irradiation in inflammatory processes hesitate to make use of the method because they fear deleterious effects on the skin or gastrointestinal disturbances such as are observed in connection with the treatment of malignant tumors. When treating neoplasms the aim is to deliver the largest dose compatible with the integrity of the

surrounding tissues. When treating inflammatory lesions, on the contrary, only small or moderate doses are employed. Doses that might strain the tolerance of the skin are unnecessary and should be avoided as potentially dangerous. For acute inflammations especially, the doses required are so small that the skin or the gastro-intestinal tract cannot possibly be affected. Hence any fear on this score is unfounded.

The treatment of inflammatory processes with roentgen rays is far from new. Indeed, it goes back to 1902 and 1903. An interesting fact is that some of the earliest therapeutic trials were made in this country, but they did not receive any attention until the successful results had been repeatedly confirmed by others here and abroad. In connection with some varieties of inflammation the idea of treating them with roentgen rays arose from the chance observation of improvement following roentgenographic exposures for diagnostic purposes.

ACUTE INFLAMMATIONS

Many varieties of acute inflammation yield rapidly to a small dose of roentgen rays. By a small dose is meant a dose representing less than half of the tolerance dose of the skin, a dose as small as a fourth of the so-called erythema dose, or even less, is often sufficient, but this may vary somewhat according to the character and stage of the lesion in each case. A significant point is that the more acute the inflammation, the smaller the dose of rays required. With such small doses there can be no question of cutaneous or systemic reaction, therefore, weak and febrile patients can be treated without danger. In most cases a single

¹ Read before the meeting of the Baltimore City Medical Society, Baltimore, Maryland, March 5, 1937.

dose of roentgen rays must be larger than the doses used for acute inflammations, and that treatment must be repeated at intervals for some time. By a larger dose is meant a dose varying between 50 and 80 per cent of the tolerance dose when given at one time or, in international units, between 300 and 500 roentgens, according to the conditions of irradiation. Rays generated at a potential between 120 and 140 kilovolts and filtered through 4 or 6 mm of aluminium are usually adequate. Rays generated at higher potentials can be used with approximately equal effect, but this involves an unnecessary waste of energy. For skin diseases, unfiltered rays or rays filtered through 2 mm of aluminium and generated at potentials of 80 or 100 kilovolts are generally preferable. The treatment of chronic inflammatory lesions with maximal (erythema, tolerance, or tumor) doses is bad practice and should be avoided as potentially dangerous. Since treatment must be repeated at intervals for varying periods, the use of maximal doses may lead to undesirable effects or, by superimposing a reactive inflammation, may cause the original inflammation to spread rather than to abate.

Tuberculous Processes—Although considerable variation may be observed in different cases, the effect of irradiation is characteristically slow. In tuberculous adenitis the affected region must be irradiated every three or four weeks for from three to twelve months. When calcification is absent, the inflamed nodes gradually recede and may disappear completely or may remain as small fibrous granules. Unless abundant, caseous material may be absorbed or may be replaced by calcium. When suppuration occurs, drainage may be advisable, but sometimes the pus can be withdrawn through a needle of large bore, which should be introduced, not through the thinnest part of the fluctuant area, but to one side through more substantial tissue, so as to avoid the formation of a sinus. The extensive surgical procedures formerly in vogue are

now seldom necessary. The resolution of tuberculous lesions appears to be hastened by supplementing periodic roentgen irradiation with daily exposure of the entire body to graduated doses of sunlight or to ultra-violet rays generated artificially. Ultra-violet irradiation confined to the affected region usually is a waste of time.

Much the same may be said of tuberculous peritonitis. An important consideration is that the entire abdominal cavity should be irradiated as uniformly as possible. This can best be done by dividing the anterior half of the abdomen from the level of the diaphragm to that of the pubic region into four fields, with the navel as the common center, the posterior half should be divided into four corresponding fields.

Physicians in general and many ophthalmologists are not aware that radiotherapy is an effective method of treating tuberculosis of the cornea or iris. The lesions recede more rapidly after exposure to roentgen rays than do similar lesions in other parts of the body. The dose of roentgen rays should never exceed three-fourths of a minimal erythema dose, a larger dose, especially in children, might lead to epithelial degeneration of the crystalline lens and to cataract.

Actinomycosis—When actinomycosis affects the face, mouth, or other superficial structures, roentgen or radium irradiation, supplemented by the internal use of large doses of iodides and sometimes by simple surgical drainage of an abscess, are the most effective therapeutic measures, and a large proportion of patients can thus be permanently cured.

Not infrequently, actinomycotic inflammation arises in the intestine, especially the lower part of the small intestine, where it is often mistaken for simple or suppurative appendicitis. In many cases, one or more operations are performed, and the true character of the process is not recognized. This is unfortunate because, if the lesion is actinomycotic in character, exploratory maneuvers or any measure

radium, applied soon after the onset, caused the inflammation to subside in most cases within from twenty-four to forty-eight hours. Moreover, suppuration usually did not occur, and the mortality was correspondingly reduced. Roentgen irradiation is just as effective but, in many cases, radium is preferable because the treatment can thus be given without disturbing the patient.

Erysipelas —When erysipelas does not complicate diabetes or nephritis, roentgen irradiation is usually followed by prompt abatement of the fever and recession of the lesions. This is especially true when the patients are adults and when the treatment is given early. In children, for some unknown reason, the disease does not respond quite so well. In some cases, after an initial period of improvement, the inflammation may again become active, and additional treatment may be required to arrest the process. When this happens, it is usually because the initial treatment was confined too closely to the apparent limits of visible involvement. Too much stress cannot be laid on the importance of including in the field of irradiation a wide zone of apparently normal tissue around the lesion. A single dose, corresponding to 150 or 200 roentgens, of rays generated at 130 or 140 kilovolts, and filtered through 4 mm. of aluminum, is usually sufficient.

Favorable results may also be obtained by exposing the affected region to a strong, erythema or blistering, dose of ultra-violet rays. A possible disadvantage may be that, during the period of cutaneous reaction to treatment, it may be difficult to know what is disease and what represents reaction. Roentgen irradiation has no such disadvantage, the dose required does not cause reactive inflammation.

Other Acute Inflammations —From time to time other acute inflammations are found to yield equally well to roentgen irradiation. Some years ago it was reported that in certain cases of acute mastoiditis, in which the mastoid region had been exposed to small doses of roentgen rays for diagnostic purposes, the in-

flammation had subsided and an operation had not been necessary. Similar reports have appeared since then, but some of these reports have been rather too casual to be convincing. I am not aware that the possible therapeutic advantage of irradiation in this condition has ever been given a serious and thorough test. This is unfortunate because, if acute mastoiditis should be found to yield as do so many other forms of inflammation, many patients might be saved some of the pain, mental stress, and cost of hospitalization associated with operations for mastoiditis. Moreover, this possibility could be tested without jeopardizing the interests of the patients in any way.

In 1936, Kelly and Dowell (19) reported that favorable results had been obtained in cases of gas-bacillus infection. According to them, the only patients who died were those whose affected extremity had been amputated. Inasmuch as the number of cases was not large and most of the patients had also been treated with serum, the evidence in favor of radiotherapy cannot be regarded as conclusive. But if Kelly and Dowell's experience should be repeated and confirmed by others, especially in cases in which patients were treated without benefit of surgery or serum, this would prove a great boon in a condition the gravity of which cannot be exaggerated.

CHRONIC INFLAMMATIONS

For years it has been known that many forms of chronic inflammation are favorably influenced by roentgen irradiation. Among these may be mentioned numerous varieties of chronic inflammation of the skin in which the therapeutic value of radiotherapy is conceded by experienced dermatologists. Other chronic inflammatory processes which may be mentioned as examples are tuberculous adenitis, peritonitis, keratitis, and iritis, actinomycosis and blastomycosis, trachoma in its early stages, and active, infectious arthritis. Two features which characterize the effect of irradiation are that the

prominent feature of the majority of acute inflammations

Pyogenic infections in general are characterized by varying degrees of leukocytic infiltration. By accumulating leukocytes, chiefly lymphocytes, polymorphonuclear cells, and eosinophils, around one or more clusters of bacteria, the body attempts to localize the infection, to destroy the invading organisms, and to neutralize their toxic products. The leukocytic infiltration also appears to be Nature's method of intensifying the production of antibodies. An additional factor is hyperemia which facilitates the mobilization of leukocytes. Of some acute inflammations, especially those caused by streptococcic infection, local infiltration by leukocytes is not a prominent feature. Against infections of this kind the body apparently defends itself by a general reaction of the leukocytes in the circulating blood.

Experiments on a large number of animals of different species and observations on human beings of the effect of roentgen rays and radium on different kinds of cells and tissues have proved conclusively that each variety of cell has a specific range of sensitiveness to irradiation. Some are extremely sensitive, even to small doses, while others are not influenced by doses many times larger. Moreover, these experimental and clinical investigations have demonstrated that the most sensitive of all cells are the lymphocytes in the spleen, lymph nodes, lymph follicles, thymus gland, circulating blood, and bone marrow. The polymorphonuclear and eosinophilic leukocytes are also sensitive, but their susceptibility to irradiation is slightly less than that of the lymphocytes.

When the entire body of an animal is exposed to a moderate dose of roentgen rays or radium, the majority of the organs remain free from perceptible abnormalities, but the spleen, lymph nodes, and intestinal lymph follicles show a destruction of lymphocytes, the degree of which varies according to the dose of rays and the inter-

val between irradiation and microscopic examination. As observed by Heineke (27), the disintegration of lymphocytes was characterized by disorganization and fragmentation of the nuclear chromatin of the cells and by scattering of the fragments of chromatin between the remaining intact cells and in the spaces of the reticular stroma, where the fragments gathered into clumps or balls. Then, the clumps or balls of degenerate chromatin were gradually taken up by some of the reticular cells, which assumed a phagocytic property and swelled as the amount of ingested chromatin debris increased. This was associated with a progressive reduction in volume of the affected lymphoid structures. Identical changes were observed in the lymphoid tissue of the vermiform appendix and in the bone marrow. The destruction of lymphocytes in the spleen and lymph nodes was often so great that most of the malpighian corpuscles or lymph follicles could be recognized only by the blood vessels and by the concentric arrangement of the stroma. A small percentage of lymphocytes appeared to resist the action of the rays. After a number of hours, the phagocytic reticular cells (macrophages) themselves began to disappear. The chromatin debris ingested by the phagocytes appeared to undergo intracellular digestion, because the number and size of the ingested fragments diminished steadily. Two or three days after irradiation, degenerative alteration of other cells, notably the polymorphonuclear leukocytes and eosinophils, also became perceptible, and many of these cells disappeared from the splenic pulp and bone marrow. From ten days to three weeks later, more or less regeneration of the lymphoid tissue became evident.

Since then, Heineke's (27) results have been confirmed by many investigators, including Krause and Ziegler (28), Fromme (29), Hall and Whipple (30), Warthin (31), Tsuzuki (32), and many others. Warthin's description of the effect of roentgen rays corroborated the observations of Heineke in every particular, ex-

beyond simple drainage of an abscess only serves to spread the infection. Thorough exposure of the entire abdomen (front and back) to about three-fourths of an erythema dose of roentgen rays may be followed by substantial improvement and sometimes by complete and permanent cure. Maximal improvement or cure requires that the treatment be repeated several times at intervals varying with the dose and the scheme of irradiation.

But when the infection has extended to the respiratory tract (bronchi, lungs, and pleura), more than slight and temporary improvement is not likely to be obtained with any method of treatment.

Trachoma—Trachoma is characterized by conjunctival granulations composed largely of lymphocytes. Gradually these granulations are replaced by connective tissue, and the eyelids become sclerosed and distorted. As early as 1902 and 1903, Mayou (20), Stephenson and Walsh (21), and Cassidy and Rayne (22) made the discovery that, in some cases, the trachomatous granulations receded after exposure to roentgen rays, and that the patients were cured. Subsequently, Thielemann (23), Cochard (24), and Meldolesi and Sabbadini (25) confirmed the favorable influence of radiotherapy. Sometimes the lesions recurred later, but resumption of treatment caused them to retrogress and disappear, this probably meant that the initial treatment had not been continued long enough. The evidence furnished by the group of writers last mentioned indicates that the action of the rays is greatest during the early stages of the granular form of the disease and least during the late stages, when the granulations have been replaced by connective tissue.

Chronic Infectious Arthritis—In many cases roentgen irradiation relieves pain, reduces swelling, and the functional disability diminishes. As might be expected, the degree of improvement varies considerably in different patients. The best results require repeated treatment and are obtained in cases in which the inflammation is active. Incidentally, a useful

indication of active inflammation is tenderness. When the inflammatory deposits have become largely or completely organized, little improvement is to be expected. Of course, focal infection must not be neglected, irrespective of irradiation.

Recently, Berck and Harris (26) reported having treated with roentgen rays 30 patients with bronchiectasis, of whom 19 are said to have derived more or less pronounced improvement. Here again an opinion about the value of irradiation will have to await corroborative testimony. However, the care with which the cases appear to have been selected and the degree of improvement obtained in many of them make this report seem worthy of attention.

MODE OF ACTION

Acute Inflammations—Numerous experiments have long since made it clear that most bacteria are not directly influenced to a perceptible degree by doses of roentgen rays or radium such as are commonly employed in treating human beings. To attribute the favorable effect of irradiation to a bactericidal action of the rays, therefore, would be to maintain an untenable hypothesis.

Anyone who has had an extended experience with radiotherapy for acute inflammations cannot have failed to be impressed by (1) the prompt relief of pain and the rapid resolution of the lesions when treated early, as well as by the acceleration of suppuration in lesions treated later, (2) by the fact that acute inflammations of different kinds respond at about the same rate to a given dose when treated at a corresponding stage, and (3) by the circumstance that a small dose of rays is sufficient to produce this effect. Since irradiation acts in the same way and in the same time on so many forms of acute inflammation, it seems logical to conclude that the lesions themselves must have some common factor. This factor appears to be the radiosensitiveness of certain cells which are a more or less

prominent feature of the majority of acute inflammations

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Experiments on a large number of animals of different species and observations on human beings of the effect of roentgen rays and radium on different kinds of cells and tissues have proved conclusively that each variety of cell has a specific range of sensitiveness to irradiation. Some are extremely sensitive, even to small doses, while others are not influenced by doses many times larger. Moreover, these experimental and clinical investigations have demonstrated that the most sensitive of all cells are the lymphocytes in the spleen, lymph nodes, lymph follicles, thymus gland, circulating blood, and bone marrow. The polymorphonuclear and eosinophilic leukocytes are also sensitive, but their susceptibility to irradiation is slightly less than that of the lymphocytes.

When the entire body of an animal is exposed to a moderate dose of roentgen rays or radium, the majority of the organs remain free from perceptible abnormalities, but the spleen, lymph nodes, and intestinal lymph follicles show a destruction of lymphocytes, the degree of which varies according to the dose of rays and the inter-

val between irradiation and microscopic examination. As observed by Heneke (27), the disintegration of lymphocytes was characterized by disorganization and fragmentation of the nuclear chromatin of the cells and by scattering of the fragments of chromatin between the remaining intact cells and in the spaces of the reticular stroma, where the fragments gathered into clumps or balls. Then, the clumps or balls of degenerate chromatin were gradually taken up by some of the reticular cells, which assumed a phagocytic property and swelled as the amount of ingested chromatin debris increased. This was associated with a progressive reduction in volume of the affected lymphoid structures. Identical changes were observed in the lymphoid tissue of the vermiform appendix and in the bone marrow. The destruction of lymphocytes in the spleen and lymph nodes was often so great that most of the malpighian corpuscles or lymph follicles could be recognized only by the blood vessels and by the concentric arrangement of the stroma. A small percentage of lymphocytes appeared to resist the action of the rays. After a number of hours, the phagocytic reticular cells (macrophages) themselves began to disappear. The chromatin debris ingested by the phagocytes appeared to undergo intracellular digestion, because the number and size of the ingested fragments diminished steadily. Two or three days after irradiation, degenerative alteration of other cells, notably the polymorphonuclear leukocytes and eosinophils, also became perceptible, and many of these cells disappeared from the splenic pulp and bone marrow. From ten days to three weeks later, more or less regeneration of the lymphoid tissue became evident.

Since then, Heneke's (27) results have been confirmed by many investigators, including Krause and Ziegler (28), Fromme (29), Hall and Whipple (30), Warthin (31), Tsuzuki (32), and many others. Warthin's description of the effect of roentgen rays corroborated the observations of Heneke in every particular, ex-

cept that, by examining the tissue soon after irradiation, Warthin found unmistakable evidence of the disintegration of lymphocytes within fifteen minutes after exposure of the animals to the rays, and the cellular degeneration continued for several days. Similar effects have been obtained with radium. Other investigators have demonstrated that the lymphocytes in the circulating blood are equally sensitive to irradiation, and that the circulating polymorphonuclear and eosinophilic leukocytes are only slightly less sensitive than the lymphocytes.

The rate at which the varieties of leukocytes mentioned are destroyed by irradiation under experimental conditions corresponds closely to the rate at which acute inflammations subside after exposure to a suitable dose of roentgen rays or radium. The only other cells in the body which are affected at anything like the same rate are the mucus secreting epithelial cells in the salivary glands, in the bronchi, and in the intestine, but since these cells could not play any part in the majority of inflammatory processes, they may be excluded from consideration.

In circumscribed inflammations the significant rôle of lymphocytes, polymorphonuclear cells and eosinophils in the defense of the organism against infection and the sensitiveness of these cells to irradiation make it appear likely that, when an inflammatory process is irradiated, the rays act mainly by destroying a proportion of the leukocytes infiltrating the lesion or circulating in the blood vessels which supply the affected area. This view is corroborated by the rapidity with which the symptoms often abate and the physical signs disappear. Moreover, microscopic examination of irradiated inflammatory lesions has repeatedly shown destruction of leukocytes, especially lymphocytes, to be the outstanding feature observed. It seems logical to conclude, therefore, that destruction of leukocytes is the primary and direct effect of irradiation. As a result of the disintegration of infiltrating

leukocytes the antibodies, ferments, and other protective substances which these cells contained are liberated in the surrounding tissue spaces, where they become mixed with the tissue fluids. It is also probable, as the experimental evidence indicates, that the next step is an increase in phagocytosis by reticular cells which become macrophages. No doubt other intimate, secondary, or indirect effects related to cell metabolism are produced, but the precise character and significance of these effects are not clear.

Since leukocytic infiltration is such an outstanding factor in the defense against infection, the natural question is why destruction of a large number of leukocytes infiltrating such lesions may not do more harm than good. The only answer is that, after small or moderate doses, no one has yet submitted any evidence of ill effects. The influence of irradiation always has been favorable or the rays have failed to alter the course of the inflammatory process. When I first attempted to ascertain the therapeutic value of irradiation for lesions of this character, this question was uppermost in my mind, and I carefully analyzed all the experimental and clinical facts. The first patients were treated with great caution. But after having treated hundreds of patients, I can testify that, although in some cases radiotherapy has not had a favorable effect, an unfavorable action has never been observed.

From the foregoing considerations, therefore, it seems not unreasonable to assume that irradiation, by destroying some of the infiltrating leukocytes, causes the protective substances in these cells to be liberated and to be made even more readily available for defensive purposes than when they were in the intact cells. This and the increase in phagocytosis which follows the disintegration of the cells represent the main effects of exposure to roentgen rays and radium and probably explain the usually favorable action of these agents. All the clinical circumstances indicate that inflammatory lesions respond to irradiation in proportion to the degree

of leukocytic infiltration. In favor of this view, held by Pordes and others, are the experimentally proved radiosensitivity of lymphocytes, polymorphonuclear leukocytes and eosinophils, the fact that the rate of regression of acute inflammations corresponds to the rate at which these cells are known to be destroyed by irradiation, and that these cells are the only cells commonly found in inflammatory lesions that could be affected at such a rapid rate by small or moderate doses. Other circumstances pointing in the same direction are that radiotherapy is most beneficial during the infiltrative stage and less beneficial during the suppurative stage, and that, although the majority of lesions yields rapidly to treatment, some respond less rapidly or do not respond at all. Variation in the degree of leukocytic infiltration of different lesions of the same character or of similar lesions of different character is a well-known pathologic fact. Therefore, the degree of leukocytic infiltration must influence the action of the rays, because the rays can destroy leukocytes only in proportion to the number of these cells. This is undoubtedly related to and probably explains the fact that, while many inflammatory lesions are influenced favorably, some react much less or do not show any reaction.

When the inflammation is not confined to a small area but is extensive or diffuse rather than circumscribed, and when leukocytic infiltration is not a pronounced feature, as in erysipelas, the rays probably act in a somewhat different manner. Under these circumstances, the smaller number of infiltrating leukocytes should prevent the rays from having the same local effect, unless some compensatory mechanism enters into play. Evidence of such a mechanism in erysipelas has not yet been demonstrated, but that such a mechanism exists is indicated by the action of roentgen rays in other diseases. In bronchial asthma, for example, irradiation of the spleen or of other parts of the body remote from the bronchi and lungs is often followed by more or less striking relief

from symptoms. What probably takes place is a destruction of leukocytes in the spleen and in the large mass of blood circulating through this organ. Then the cellular debris and the contents of the destroyed cells find their way into the general circulation, where they have been shown to produce a protein-like reaction. In inflammations that are not circumscribed and in which leukocytic infiltration is comparatively slight, the affected area is hyperemic and the vessels are more or less gorged with blood. Wide exposure of such an area to a small dose of rays undoubtedly causes many leukocytes to disintegrate, and the contents of the destroyed cells are liberated into the blood and throughout the tissue spaces. And the destruction of leukocytes is probably followed by changes similar to those described in connection with more limited inflammations. At least this would seem to be the most logical conclusion. Any other assumption would be inconsistent with the known facts and with the clinical behavior of this kind of inflammation.

Chronic Inflammations—To understand the influence of irradiation on chronic inflammations it is necessary to bear in mind a few essential points. Depending on their character and on the etiologic factors which produce them, such lesions are characterized by varying degrees of leukocytic infiltration, connective tissue proliferation, and caseous or calcareous degeneration. Moreover, the clinical effect of irradiation is slow, and maximal improvement or cure requires repeated treatment at intervals. From what is known about the action of roentgen rays and radium on different varieties of cells and tissues, it seems most likely that these factors are closely related. Since they are products of cellular degeneration, cheese and chalk should not be influenced by irradiation, and this is precisely what is observed in practice. As we have already seen, the varieties of leukocytes which are such an important feature of inflammatory infiltration are exceptionally sensitive to roentgen rays or radium. Connective

tissue cells, on the contrary, are comparatively resistant to irradiation, they are even less sensitive than the epithelium of the skin. In this respect the difference between lymphocytes or polymorphonuclear leukocytes and connective tissue cells is tremendous. Analysis and correlation of these several factors would seem to furnish a satisfactory explanation of the effect of radiotherapy on chronic inflammatory processes. The greater the degree of leukocytic infiltration in proportion to connective tissue proliferation, the more marked and the more rapid is the influence of the treatment, and *vice versa*. If tuberculous lesions are taken as an example, it is well known that the effect of irradiation is greater during the infiltrative phase of the tubercles, when leukocytic infiltration is most pronounced than it is when the leukocytic infiltration has diminished and has passed into an advanced stage of caseous degeneration or of repair by connective tissue or by calcification. It is probable, therefore, that leukocytic infiltration, on the one hand, and connective tissue proliferation on the other, act in opposite directions, the former tending to increase the effect of irradiation and the latter tending to diminish or retard this effect. This conclusion is in complete harmony with the experimental evidence and with all the clinical observations which have been recorded.

In conclusion, one point should be strongly emphasized. When dealing with inflammations, the therapeutic radiologist must, as far as dosage is concerned, think in terms quite different from those that apply to malignant tumors. Even when treatment must be repeated many times, the dose of rays should never be sufficient to tax the tolerance of the tissues. Otherwise, the condition of some patients may be worse after treatment than before.

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ROENTGEN IRRADIATION OF THE HYPOPHYSIS¹

By JOHN H. LAWRENCE, M.D., WARREN O. NELSON, M.D., and
HUGH WILSON, M.D.

From the Departments of Internal Medicine and Anatomy, and the Division of Roentgenology, Yale University School of Medicine, New Haven, Conn., and from the Department of Anatomy, Wayne University School of Medicine, Detroit, Michigan

IN view of the increased interest in the pituitary body in relation to experimental and clinical endocrinology, and because of the frequent attempts to influence disease through irradiation of the adenomatous or non-adenomatous gland, it has seemed important to study the effects of irradiation of the normal pituitary body of the white rat.

During the past twenty years there have been numerous reports on the effects of irradiation of the hypophysis for various gynecological conditions, with varying results. Recently, irradiation of the pituitary has been extended to patients with diabetes mellitus and so-called essential hypertension, again with varying results. The question naturally arises, can the non-adenomatous pituitary gland be influenced with therapeutic doses of x-rays? A partial answer to this question could probably be obtained through animal experimentation. Apparently the first studies on the effects of pituitary irradiation in animals were made by Strauss (1) and Brunner (2), working independently in 1920. Strauss noted histologic changes in the pituitary body of the guinea pig after irradiation, but no changes in the other endocrine glands. Brunner irradiated the whole heads of young cats and puppies, and in addition to very slight histologic changes in the nervous tissue he found some histologic changes in the anterior pituitary. There was some suppression of growth after irradiation. Fraenkel and Geller (3), in 1921, irradiated the pituitary regions of young female rabbits. The irradiated animals grew less rapidly than the controls, and when killed they showed definite under-

development of the genital organs, including small uteri and small ovaries with infantile follicles. The pituitary bodies of the experimental animals were small, and many of the cells in the anterior and middle lobes had indistinct boundaries and contained irregular pyknotic nuclei. There was, however, no characteristic change in any particular cell. In 1922 Rahm (4) irradiated the hypophyseal regions of young rabbits. With smaller doses he noted stimulation of growth, and larger doses caused cessation of growth. There were no histologic studies.

Ghilarducci (5) also used young rabbits and claims to have found that many animals died after irradiation. At autopsy the internal organs were normal but there were skeletal changes with deformity, and complete destruction of the anterior pituitary glands, but apparently no changes in the ovaries or other endocrine glands.

Podljaschuk, in 1927 and 1928 (6-a and 6-b), using young and mature rabbits and dogs, and giving more than an erythema dose to the pituitary region, observed incessantly, suppression of growth, and under-development of sex organs with histologic changes in the pituitary body. Del Buono (7), using slightly less than a skin dose in adult dogs, could demonstrate no structural changes in the hypophysis or other organs, six months to one year after irradiation. Mahnert (8) irradiated infantile white mice and observed inhibition of body growth and delayed estrus, associated with small uteri, also small ovaries with fewer ova, many in a degenerate condition. His method of irradiation is not given, so the effects may have been due to general irradiation of the whole body, in view of the small doses (100 r).

¹ This work was supported by a grant from the Fluid Research Fund of the Yale Medical School.

Vischia (9), irradiating the hypophyseal regions of mature dogs, killed them after three months and found no histologic changes in the pancreas, suprarenals, or thyroid glands. No histologic studies of the hypophysis are given. Martinalli (10) observed no histologic changes in the pituitary of sexually mature rabbits after irradiation, but there was an increase in the interstitial tissue of the ovaries, and a decrease in the number of follicles. The uterine walls were hypertrophied. Some of the animals lost weight. Stockl (11) noted a decreased excretion of prolan A in the urine of young rabbits after irradiation. In 1932, Epifanio and Cola (12), irradiating young and adult rabbits, concluded that 25 per cent of an erythema dose accelerated growth, but that doses greater than an erythema caused suppression of growth. Some of the animals receiving the larger doses died, after losing weight and sex function, and having terminal convulsions. There were changes in the cells of the anterior lobe, the acidophiles being the most affected, and the testicles were decreased in size.

After irradiating young guinea pigs over the hypophyseal area, Mighavacca (13) observed atretic ovarian follicles and infantile uteri. In the older animals the changes were less marked. There were no microscopic studies of the pituitary body. Selle, Westra, and Johnson (14) studied the effect of pituitary irradiation on depancreatized diabetic dogs. Doses as high as 3,000 r were given. Histologically, the hypophyses showed congestion and degeneration and also some degenerative changes in the nervous tissue of the brain, but in spite of this there was no amelioration of the diabetes. Fehr (15), working in Lacassagne's laboratory, gave massive and fractional doses over the pituitary regions of sexually mature rabbits. The massive doses varied from 2,360 r to 2,645 r and the fractional doses varied from 3,300 r to 10,160 r. He calculated the dose reaching the pituitary to be about 80 per cent of the skin dose. After a single massive dose there was some loss of weight, but a gain

occurred after fractionated treatment. The animals were killed four to six weeks after irradiation. There were no histologic changes in the hypophyses, and the other glands of internal secretion were normal except after massive irradiation, in which case the ovaries were small and had small follicles. The uteri were also small. These latter changes were not interpreted as results of pituitary irradiation. Fehr concluded that the pituitary of the rabbit is very radioresistant and cannot be influenced with ordinary doses of x-ray.

From the above summary of the literature concerning hypophyseal irradiation, one can conclude that the hypophyses of various laboratory animals are not very radiosensitive, although it is difficult to determine the doses used by most of the workers. The varying doses used, probably explains the lack of uniformity in the results obtained. There has also been no characteristic histologic picture in the pituitary body. In view of these inconclusive findings, we have studied the effects of pituitary irradiation on a large group of young female albino rats. No previous worker has used white rats, and since the endocrine system of these animals has been well studied and standardized histologically, they seem ideal for this purpose.

METHODS

Albino female rats, 30 to 40 days of age (usually litter mates), were used in each experiment. Under amytal anesthesia (controls included), the pituitary regions were exposed to filtered x-rays as follows: 180 kv, 25 ma, filter 0.5 mm Cu and 1 mm Al, 50 cm distance, giving 52 r per minute. Except for an opening 1 cm in diameter over the dorsum of the head directly over the hypophysis, the animals were shielded with lead. In a few animals the thyroid region was irradiated. Still others received the course of irradiations but the entire animal was protected with a lead shield. Control animals were given amytal at the time the experimental animals were irradiated. For several

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TABLE I—EFFECT OF IRRADIATION OF PITUITARY REGION OF RATS WITH 180 KV FILTERED X-RAYS

Before Irrad.			After Irrad		Remarks
No of Rat	Wt gms	Dose in r	Day of Exp	Wt gms	
12	50	Control	22	110	Killed on 23rd day
14		513 r on 1st, 7th, 14th and 18th days	22	93	Killed on 23rd day
15	50	Control	22	114	Killed on 23rd day
16	51	Same as No 14	18	105	Died on 19th day
17	48	Same as No 14	22	98	Killed on 23rd day
18	48	Same as No 14	18	101	Died on 19th day
19	46	Control	22	109	Killed on 23rd day
20	55	513 r on 1st 7th, and 11th days	17	75	Killed on 20th day
22	57	Same as No 20	17	89	Killed on 20th day
23	53	Control	17	101	Killed on 20th day
24	54	513 r on 1st 7th 11th and 17th days	18	93	Killed around 19th day
25	54	Same as No 24	17	77	Died on 18th day
26	55	Control	18	101	Killed around 19th day
31	56	1 040 r on 2nd and 8th days	13	46	Killed on 19th day
32	68	Control	41	148	Killed on 41st day
34	58	Control	13	103	Killed on 19th day
35	58	Same as No 31	41	110	Killed on 41st day
37	67	Control	41	119	Killed on 41st day
40	58	1 040 r on 2nd and 8th days	41	98	Killed on 41st day
41	65	1 040 r on 3rd and 10th days	76	134	Died on 107th day
43	67	1 040 r on 2nd and 11th days	41	109	Died on 41st day
44	69	Control	76	187	Died on 76th day
47	63	Control	133	170	
48	63	925 r on 3rd and 8th days	13	80	Killed on 59th day
49	57	Control	13	82	Killed on 59th day
50	67	1 040 r on 3rd and 8th days	132	140	
53	60	1 040 r on 4th and 13th days	109	140	
54	60	Same as 53	27	95	Died on 32nd day
56	65	Same as 53	75	105	Died on 110th day
57	60	Control	109	165	
59	55	Control	58	175	(All killed on 58th day)
61	50	1 040 r on 5th 13th and 32nd days	58	120	
62	50	Hypophysectomy on 5th day	58	85	
66	40	Control	118	200	
70	40	Control	118	185	
71	45	1,040 r on 2nd and 7th days	64	110	Epilation not over pituitary Killed on 64th day
72	40	1 040 r on 2nd and 7th days	64	45	Died on 64th day
73	40	Control	64	115	Killed on 64th day
74	40	1 040 r on 2nd and 7th days	64	110	Epilation not over pituitary Killed on 64th day
76	40	Hypophysectomy on 7th day	64	70	Killed on 64th day
77	40	1 040 r on 2nd and 7th days	111	105	Died on 117th day
78	40	1 040 r on 2nd and 7th days	85	75	Died on 93rd day
79	40	1 040 r on 7th day	111	150	Received one dose of irradiation only
82	35	Control	111	155	
87	45	1 040 r on 1st and 4th days	27	40	Died on 28th day
88	40	1 040 r to thyroid on 1st and 4th days	28	85	Killed on 28th day
89	40	Control	28	95	Killed on 28th day
93	70	1,040 r to thyroid on 1st and 6th days	78	120	(All killed on 78th day)
95	65	1 040 r to pit on 1st and 6th days	78	95	
96	70	Control	78	135	
98	50	1 040 r to thyroid on 5th and 11th days	56	125	
99	60	Same as 98	56	130	
101	50	1 040 r over animal covered with lead on 5th and 11th days	56	130	
102	60	Same as 101	56	130	
104	65	1,040 r on 1st day	3	62	Killed 3rd day after irrad
106	55	1 040 r on 1st day	3	56	Killed 3rd day after irrad
108	60	Control	3	65	Killed 3rd day after irrad

weeks following irradiation, the animals were observed daily and frequently weighed. After a shorter or longer period week after irradiation. As shown in Figure 1, animal No 50, which received pituitary irradiation, weighed at the end of 148

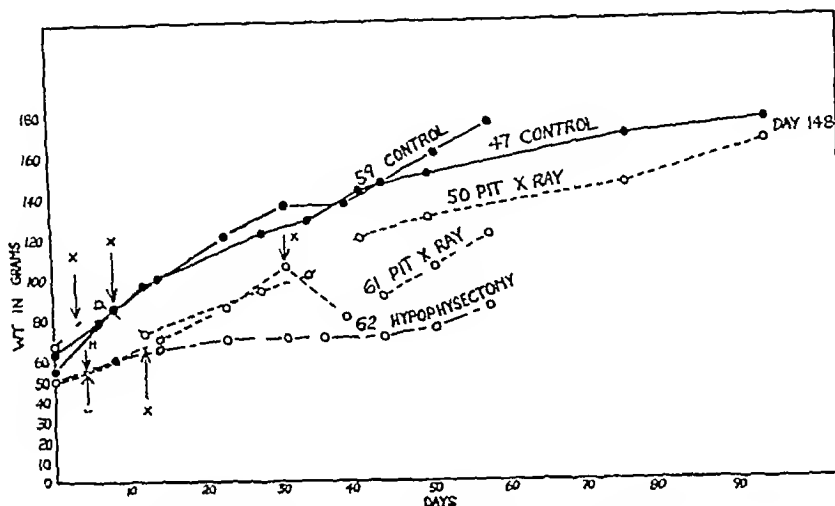


Fig 1 Growth curves of two control rats, two irradiated and one hypophysectomized (X = irradiation to pituitary H = hypophysectomy)

of time, many of them were killed and autopsies were performed. The endocrine glands were examined grossly and microscopically.

RESULTS

In Table I are tabulated the weights before and after irradiation with various doses. In the earlier experiments the animals were irradiated with 513 r at three or four different sittings, about five days apart. The inhibition of gain in weight was not striking, so that subsequently two doses of 1,040 r were given with a short interval between the two treatments. In all cases there was a subsequent temporary suppression or retardation in gain in weight.² Figure 1 shows the weight curves of a group of animals, one of which was hypophysectomized. The animals receiving irradiation gained much more slowly than the controls, the curves lying between those of the control and hypophysectomized animals. With these doses the retardation of gain in weight seemed to begin about one

days, nearly as much as the control No 47. From these and other growth curves, it is difficult to determine the duration of the effect of irradiation on growth, but in most instances it did not last for more than ten days, the rate of growth subsequently showing an increase to parallel that of the controls. Often the irradiated animals developed the soft coats characteristic of the completely hypophysectomized animal. A few of the animals died sometime after irradiation, but this was not usual. The terminal coma was not relieved by subcutaneous glucose, so the deaths were presumably not due to hypoglycemia. A small group have been kept one year after treatment, and seem to be normal. No mating experiments for the purpose of determining fertility have been carried out.

A study of the individual and average weights of the adrenals, thyroids, and pituitaries of the irradiated and control animals (Table II) will show that the organs of the former were consistently smaller than those of the controls. As the averages include a number of animals which had shown, as judged by their body weights, a recovery from the effect of the

² In a few cases in which there was no definite suppression the site of epilation over the rat's head indicated that the irradiation was off-center.

TABLE II

	Animal No	Autopsied Day of Experiment	Ovarian Wgt (mgm)	Uterine Diam (mm)	Vagina	Stage of Cycle When Killed	Adrenal Wgt (mgm)	Pituitary Wgt (mgm)
C	12	23	60	2 5				
X	14	23	42	3 0	Open	Dioestrus	42	8 5
C	15	23	58	3 2	Open	Proestrus	33	6 0
X	17	23	38	3 8	Open	Proestrus	43	8 2
C	19	23	45	2 2	Open	Oestrus	38	6 5
X	20	20	10	1 5	Closed	Dioestrus	40	8 0
X	22	20	16	1 5	Closed	Dioestrus	28	5 0
C	23	20	42	3 0	Open	Dioestrus	32	6 2
X	24	19	28	2 0	Closed	Proestrus	42	8 5
X	25	18	25	2 0	Closed	Dioestrus	37	7 2
C	26	19	39	2 5	Open	Dioestrus	30	6 0
X	31	19	24	1 2	Open	Dioestrus	41	8 3
C	32	41	42	3 5	Closed	Dioestrus	27	5 1
C	34	19	48	2 8	Open	Oestrus	44	9 0
X	35	41	31	1 8	Open	Metoeestrus	40	8 7
C	37	41	45	3 0	Open	Dioestrus	31	4 8
X	40	41	37	2 8	Open	Proestrus	46	9 3
X	48	59	23	1 5	Open	Proestrus	38	7 8
C	49	59	43	2 0	Open	Dioestrus	37	5 5
X	54	32	32	3 3	Open	Dioestrus	43	8 4
C	59	52	63	2 8	Open	Oestrus	36	6 5
X	61	53	29	2 0	Open	Metoeestrus	59	9 0
H	62	58	19	1 7	Closed	Dioestrus	29	4 5
X	71	64	38	2 5	Closed	Dioestrus	16	
X	72	64	15	1 2	Open	Proestrus	39	6 5
C	73	64	54	2 8	Closed	Dioestrus	27	4 8
X	74	64	37	3 3	Open	Dioestrus	43	8 5
H	76	64	11	1 2	Open	Proestrus	38	7 0
X	77	117	20	1 8	Closed	Dioestrus	14	
X	78	93	22	1 5	Open	Dioestrus	27	6 0
X	87	28	17	1 3	Open	Dioestrus	24	4 5
XT	88	28	38	2 8	Closed	Dioestrus	23	4 0
C	89	28	42	3 0	Open	Proestrus	39	7 3
XT	93	78	45	2 5	Open	Proestrus	42	7 5
X	95	78	27	2 0	Open	Dioestrus	44	10 5
C	96	78	43	3 2	Open	Dioestrus	31	4 5
X	104	4	14	1 5	Open	Proestrus	42	9 0
X	106	4	15	1 2	Closed	Dioestrus	26	4 8
X	108	4	14	1 2	Closed	Dioestrus	23	5 1
							27	5 0

	Ovaries (mgm)	Averages Adrenals (mgm)	Pituitaries (mgm)
X rayed (19) animals	26	31 5	5 7
Controls (13) animals	48	43 5	8 5
Hyp ³ (2) animals	15	15	

³ Although only two hypophysectomized animals are included in this series data from over 20 young females hypophysectomized in a different experiment present confirmatory averages

C = Control X = X ray to pituitary XT = X-ray to thyroid H = Hypophysectomy

irradiation, the differences would be even more striking if only the animals under the more immediate influence of the irradiation had been included. A comparison of the organ weights for the irradiated animals with those of the hypophysectomized animals shows that the impairment in-

duced by irradiation is not so marked as that following hypophysectomy. Indeed, the weights of the organs of the irradiated animals — and this is reflected in the histology of the organs — closely resembles that seen in cases of sub-total hypophysectomy.

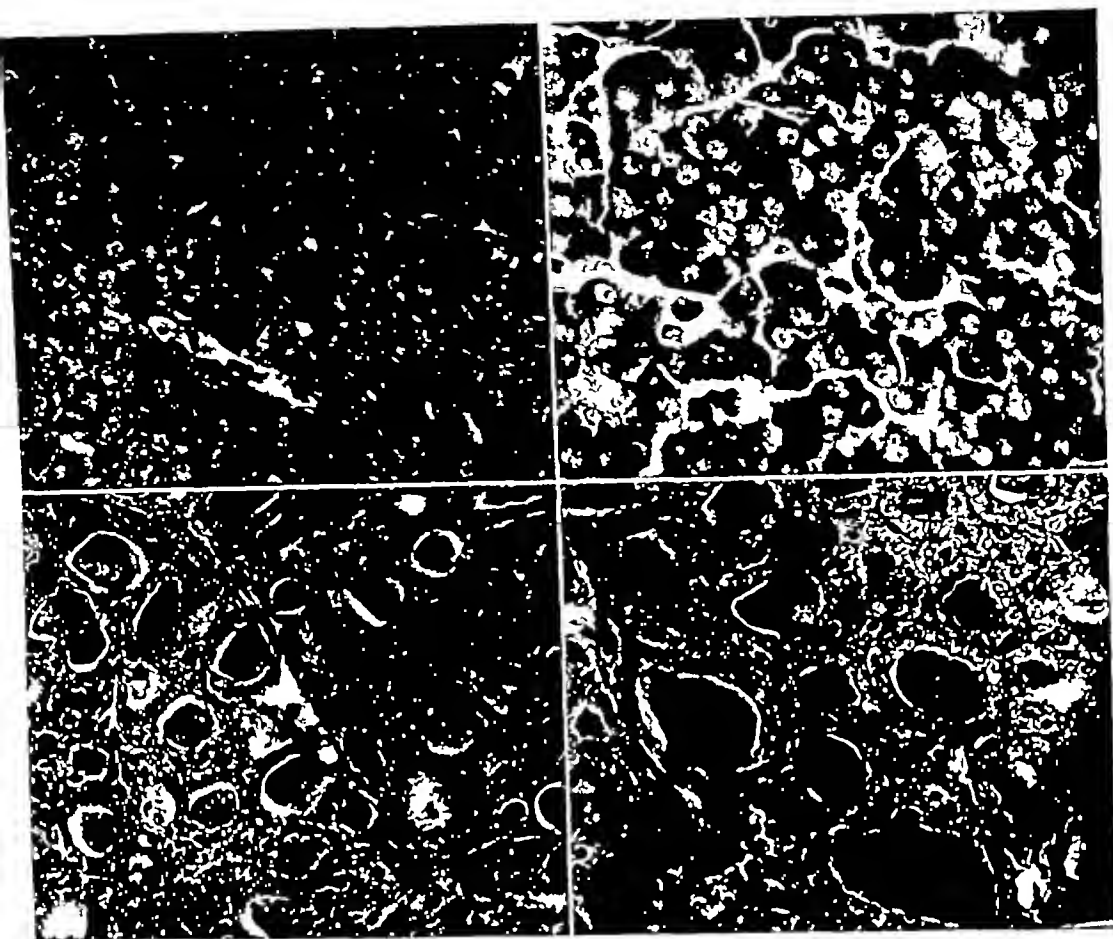


Fig 2 (*upper left*) Hypophysis of Rat 20 (x rayed) Sacrificed on twentieth day of experiment Note absence of acidophiles and presence of numerous large basophiles This selected area shows very few pyknotic nuclei ($\times 840$)

Fig 3 (*upper right*) Hypophysis of Rat 23, control for No 20 Note presence of acidophiles The basophiles while fairly plentiful are smaller and less numerous than for Rat 20 ($\times 840$)

Fig 4 (*lower left*) Thyroid of Rat 20 Note low epithelium ($\times 260$)

Fig 5 (*lower right*) Thyroid of Rat 23 Epithelium is normal in height ($\times 260$)

All tissues have been fixed in Zenker-formol, embedded in paraffin, sectioned, and stained with either modified Mallory or Masson stains

The typical picture observed in the hypophyses of the animals sacrificed from 18 to 22 days after irradiation is shown in Figure 2 The most striking difference between the experimental and control (Fig 3) hypophyses is the scarcity of acidophiles in the former Although no cell counts have been made in this study it is estimated that the granulated acidophiles are decreased from 50 to 75 per cent in the irradiated animals

The basophiles, although less markedly affected than the acidophiles, show definite changes In contrast to the acidophiles the number of basophiles is not reduced Indeed, the pituitaries of the irradiated animals show a larger number of basophiles than are present in the hypophyses of the controls Most of these basophiles are smaller than the usual granulated basophiles and the granules are distinctly clumped Many nuclei in both basophiles and acidophiles are pyknotic

The chromophobes have shown no significant change following irradiation except for the occurrence of pyknotic nuclei

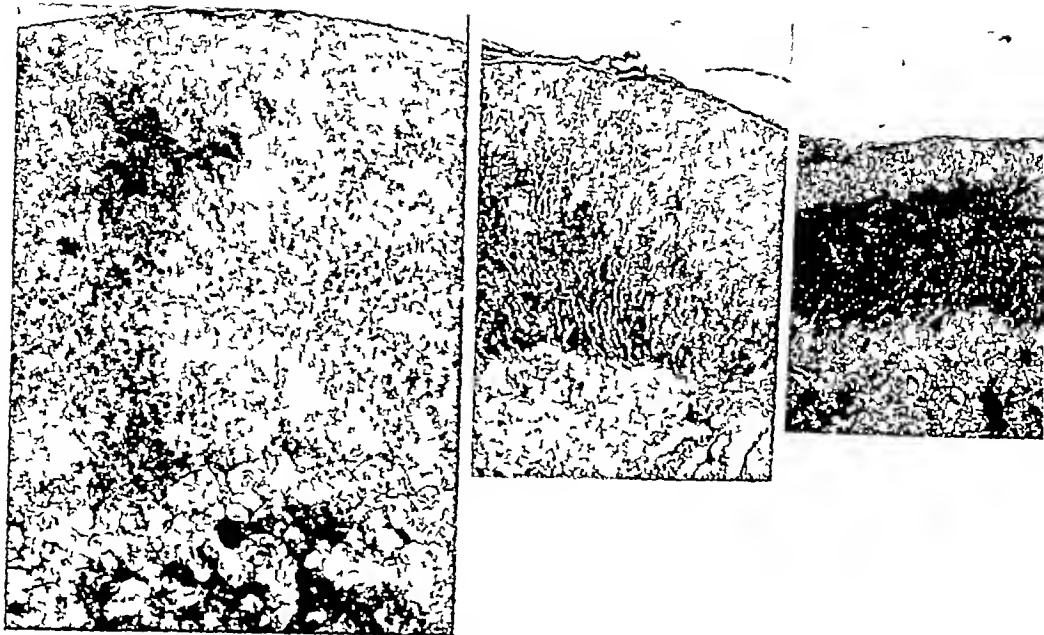


Fig 6 Adrenals of three animals The one on left is of Rat 59 (control) the middle section is of Rat 61 (pituitary X-rayed and animal sacrificed on fifty eighth day) the section on right is of Rat 62 (hypophysectomy) Note decrease in cortical tissue in X-rayed and hypophysectomized animals ($\times 50$)

and, of course, an increased number due to the decrease in acidophiles. It is quite possible that the chromophobes showing pyknotic nuclei were either basophiles or acidophiles at the time of irradiation and subsequently had undergone degranulation to a chromophobic condition.

The above description of the anterior pituitary of irradiated animals holds particularly for those sacrificed less than 27 days after irradiation. In animals sacrificed at later dates the hypophyses show, in most instances, definite evidence of recovery. The picture has varied from one similar to that already described to an almost normal condition.

There have been no significant changes in the posterior or intermediate lobes. In the latter, pyknotic nuclei are slightly more numerous than is observed in normal glands. The pituitaries of the animals sacrificed a few days after a single irradiation have shown little change.

The thyroids of the irradiated animals have been consistently smaller than normal. The follicles are smaller and the cells of the thyroid epithelium are low (compare

Figs 4 and 5). This condition is similar to that observed in the thyroids of hypophysectomized animals.

The adrenals of the irradiated animals were smaller than normal (Table II). The histologic picture shows this to be due to decrease in cortical tissue, the medulla exhibiting little change. Although in this respect the effect of irradiation resembles that of hypophysectomy, close scrutiny of the cortical layers shows that the damage resulting from irradiation is much less severe than that following ablation of the pituitary (see Fig 6).

The ovaries of irradiated animals have been consistently smaller than those of their controls (Table II). In the animals sacrificed less than 27 days after irradiation, corpora lutea were present in only one. Small follicles were present in these ovaries. All control animals of this group have shown at least two sets of corpora lutea (see Fig 7). The ovaries of eight of the twelve animals continued for longer periods after irradiation showed corpora lutea. Two of these were rats, Nos 71 and 74, in which the epilated area

indicated that the irradiation had been directed to one side of the hypophysis. The ovaries of these animals showed two

tures of the rat thyroid since all of our animals were sacrificed some time after treatment.



Fig 7 On the left is ovary of Rat 23 (control). Several corpora lutea and large follicles are present. On right is ovary of Rat 22 (pituitary irradiated). Note small size and absence of corpora lutea ($\times 11$).

sets of corpora lutea. In the ovaries of the other six, only single sets of corpora lutea were present.

The uteri and vaginae of irradiated and control animals corresponded closely with the condition of the ovaries. In instances in which the ovaries were infantile the uteri were small and thread-like and the vaginal mucosae low and castrate in type. In the other irradiated and in the control animals, the uteri and vaginae showed conditions in harmony with the conditions of the ovaries from the same animals.

The vaginal smears of many of our animals were followed for a part or all of the post-irradiation period. The observations gathered by this procedure were in harmony with the condition of the ovaries and sex-accessories.

The possibility that the effects we have observed in our irradiated animals were due in part to a scatter of the x-rays to the thyroid glands seems to have been controlled by the study of animals whose thyroids only were irradiated. In these animals there was no significant disturbance in the growth rate, and the histologic condition of the hypophyses, adrenals, and ovaries was normal. The thyroids showed no effect of the irradiation. We are unable to make any statement concerning the immediate effect of irradiation on the histologic pic-

DISCUSSION

Irradiation of the pituitary region, as carried out in our study, seems definitely to have depressed the activity of the anterior pituitary. This has been reflected in the suppression of growth, of ovarian activity, and in an atrophic condition of the thyroid and adrenal glands.

The preliminary studies made to determine the dosage of irradiation required to suppress hypophyseal activity show that the pituitary is relatively radioresistant. Furthermore, the irradiated gland is not permanently damaged as is shown by a gradual return of its structure and function to normal, or almost normal, conditions.

The pituitaries, ovaries, thyroids and adrenals of irradiated animals were definitely decreased in size. Inasmuch as these animals failed to grow normally we have considered the possibility of the lowered organ weights being simply expressions of the lower body weight. However, a comparison of the weights of such organs as the kidneys, liver, and heart expressed in terms of body weight with similarly expressed weights of pituitary, ovaries, thyroids, and adrenals has shown that the weights of the latter were less than would be expected on the basis of lower body weights only.

We are aware of the possibility that dam-

age to the hypothalamic region of the brain may have contributed to the effects we have observed. There is increasing evidence that this region of the brain may be related to anterior lobe activity. Its relation to the posterior lobe has been adequately demonstrated by Fisher, Ingram, and Ransom (16). We are unable to do more than call attention to the possibility that damage to the hypothalamus may have been a factor in our experimental results inasmuch as no examinations of the brains of our animals were made. The clinical picture we have observed is that of a deficiency of anterior pituitary hormones. The possibility that this deficiency may have been due in part to disturbed neurohypophyseal relations must await further study.

CONCLUSIONS

1 After irradiation of the pituitary regions of female albino rats 30 to 40 days old, there is a temporary decrease in the rate of growth.

2 Histologic examination of the pituitary glands consistently reveals characteristic changes which presumably account for the retardation of growth, the inhibition of ovarian activity, and the atrophic condition of the thyroid and adrenal glands.

3 From these observations it is fair to conclude that although the pituitary glands of young albino rats are relatively radioresistant, nevertheless they can be influenced by x-ray. The immediate period of suppression is followed by a gradual recovery of the pituitary and consequently, of the organs influenced by its hormones.

4 No definite clinical implications can be drawn but these experiments suggest that it is not unlikely that the non-adenoma-

tous human hypophysis can be influenced with therapeutic doses of x-rays.

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THE ROENTGEN ANATOMY OF THE KNEE JOINT AN EXPERIMENTAL ANALYSIS¹

By ERNST LACHMANN, M D, *Oklahoma City, Oklahoma*

X-ray Laboratory, Department of Anatomy, School of Medicine, University of Oklahoma

INTRODUCTION

THROUGH their classical investigations concerning the analysis of bone form and bone transformation, Wolff and the earlier writers in the second half of the last century presented us with an understanding of bone architecture. Surprisingly enough this has never been followed by a systematic and detailed analysis of the skeleton as it presents itself in the living by means of the x-ray method. Here we see the three dimensions of bodily form, lacking depth, projected on the film in two planes only, thus making definition of the bony pattern an object of special analytical investigation. While study of the x-ray pattern of bones is based essentially on analysis of the bone architecture advanced by anatomists, roentgenology may, on the other hand, furnish information valuable to the anatomist. An impression of "the typical" (Francke) features of bone architecture, which cannot be secured by study of separate bone sections, will be produced by an x-ray image, which is the resultant of all the superimposed layers of bone in a given projection. Furthermore, radiographic study is the only method of analysis of normal and pathologic bone structure in the living, and in valuable anatomical specimens which should not be subjected to dissection.

Most authors who have concerned themselves with interpretation of the x-ray pattern of bones have used the method of comparative study of object and radiogram. This in itself proved insufficient to solve the more difficult problems of radiographic analysis. The study of Spalteholz specimens, *i.e.*, of bones made translucent by chemical treatment, while

of distinct advantage in the analysis of radiograms, is of limited value for many of the problems of this paper. Besides, good results on larger and more complicated adult bones are hard to obtain and the specimens on the market are rather expensive. Stereography, although well fitted to give us an image comparable to the true object, is also unable to supply us with exact information as to the anatomical substrate of a certain line in the x-ray film. "Summation pictures cannot be united to a stereo effect since the real points pertaining to them are present neither on the picture nor in the object" (Francke). The object of the present report is the systematic analysis of the roentgenogram of the knee joint which requires detailed study on account of its complicated appearance and the clinical importance of the region.

METHODS OF STUDY

Four experimental methods of x-ray analysis were utilized. Roentgenograms were made before and after the following procedures:

(1) Chemical decalcification of the bony cortex or the spongy structure. Details of this method, which was used to determine the limitations of x-ray diagnosis of osteoporosis, are discussed in a previous paper (Lachmann and Whelan).

(2) Mechanical removal of cortex or spongy structure by means of emery wheels, files, drill-bits, and dental burs (for removal of the spongy structure the bone was first sawed in frontal section).

(3) Serial sections of bones in frontal or sagittal planes perpendicular to the x-ray beam (see Figs 1-A and 1-B). Simultaneously the bone was rebuilt, section by section, radiograms being taken at each stage.

¹ Aided by a grant from the Research Appropriation of the University of Oklahoma Medical School

(4) Production of small defects at various levels within the cortex or trabecular structure, or within both, and examination

holz, Cohn, Grashey, Brailsford) Valuable details are pointed out by Köhler ("The Borderlands of the Normal and

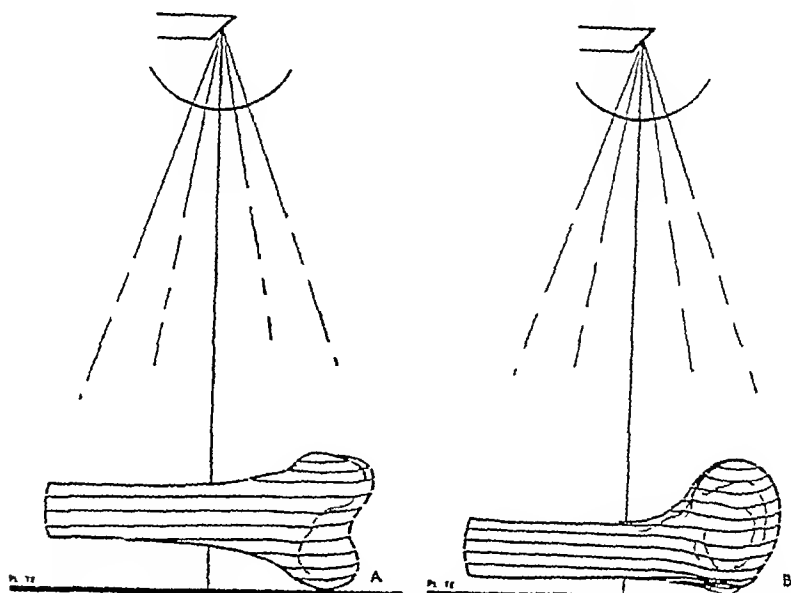


Fig 1 X ray analysis by serial sections Bone is cut in sagittal (A) or frontal (B) planes perpendicular to the x ray beam. Slices are removed section by section, and roentgenograms are taken at each stage. Simultaneously the bone is rebuilt, section by section, and roentgenographed.

by radiograms taken before and after the defects had been filled with an opaque medium. This method has great importance from the clinical point of view since it gives us an understanding of the x-ray visibility of destructive bone lesions (Chasin), in this connection it will be discussed in another report.

The four procedures outlined are all suitable for demonstrating the relative effects produced on the roentgenogram by the two components of bone, *viz*, the cortex and the spongy layer. Procedure No. 3 is especially useful as a means of identifying a given line or point on the radiogram. Procedure No. 4, as already noted, is peculiarly adapted to show the limitations of the x-ray method.

X-RAY ANATOMY OF THE KNEE JOINT

A number of the more evident points in regard to the x-ray anatomy of the knee joint are discussed or illustrated in the appertaining text-books and atlases (Spalte-

Early Pathological in the Skiagram") The bony development of the knee joint is considered in the atlas by Wilms and Sick, the work of Ruckenstein, the extensive papers by Cohn, and by Ludloff. Filling of the knee joint with air or contrast medium is taken up by Hoffa, Boyd, Colp and Klingenstein, Bernstein and Arens, Simon, Hamilton and Farrington, the latter with extensive literature. The x-ray anatomy of the joint space and special projections for the demonstration of the intercondyloid fossa are discussed in the monograph by Hulten, the latter problem also by Kayser, and by Danelius and Miller, the former by Bauer and by Popovic and Doric. Joachimsthal treats of the structure, position, and anomalies of the patella.

One of the major problems pertaining to the x-ray anatomy of the knee joint which never has been sufficiently discussed is the relative part played, in producing the roentgenogram, by the two structural

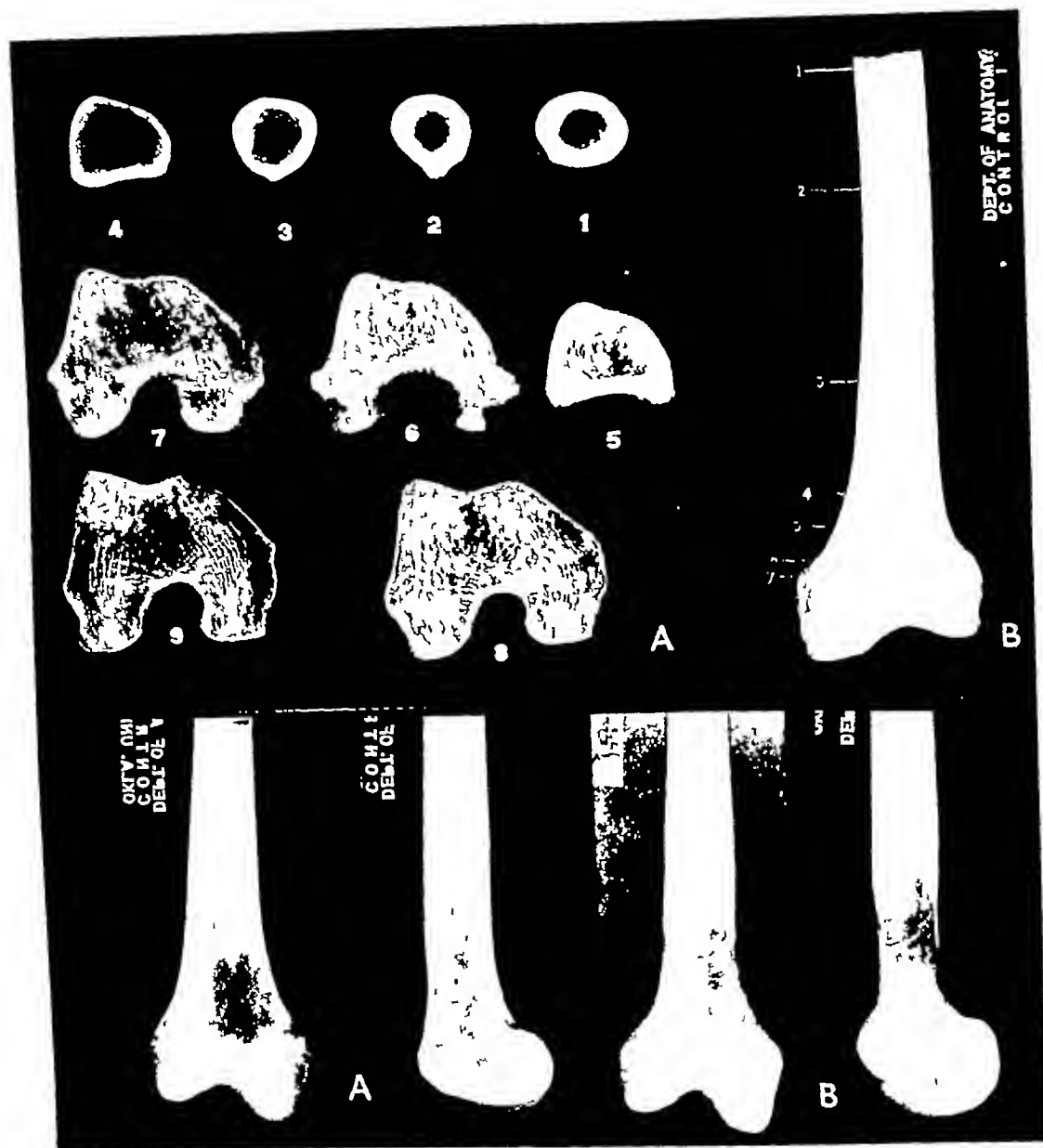


Fig 2-A (upper) Roentgenograms of horizontal sections through shaft and distal end of femur. In the horizontal sections the lateral condyle is on the left, the medial on the right. Figures in B indicate levels of sections.

Fig 3-A (lower) Roentgenogram of the distal end of a normal macerated femur.

Fig 3-B The cortex has been almost completely removed in the condylar and supracondylar portion of the same femur. The exposure has been adjusted to the greater translucency of the bone.

elements composing bone. Nevertheless this seems to us one of the fundamental questions in the analysis of a roentgenogram. The practical importance is evident. If we were able to show that one element, for instance, the cortex, is of greater significance than the other,

we can immediately conceive of lesions of the spongy portion which may not be visible on the x-ray film and *vice versa*. Roentgenograms of cross-sections through the lower two-thirds of the femur at different levels (Figs 2-A and 2-B) show the relative thickness of cortex and

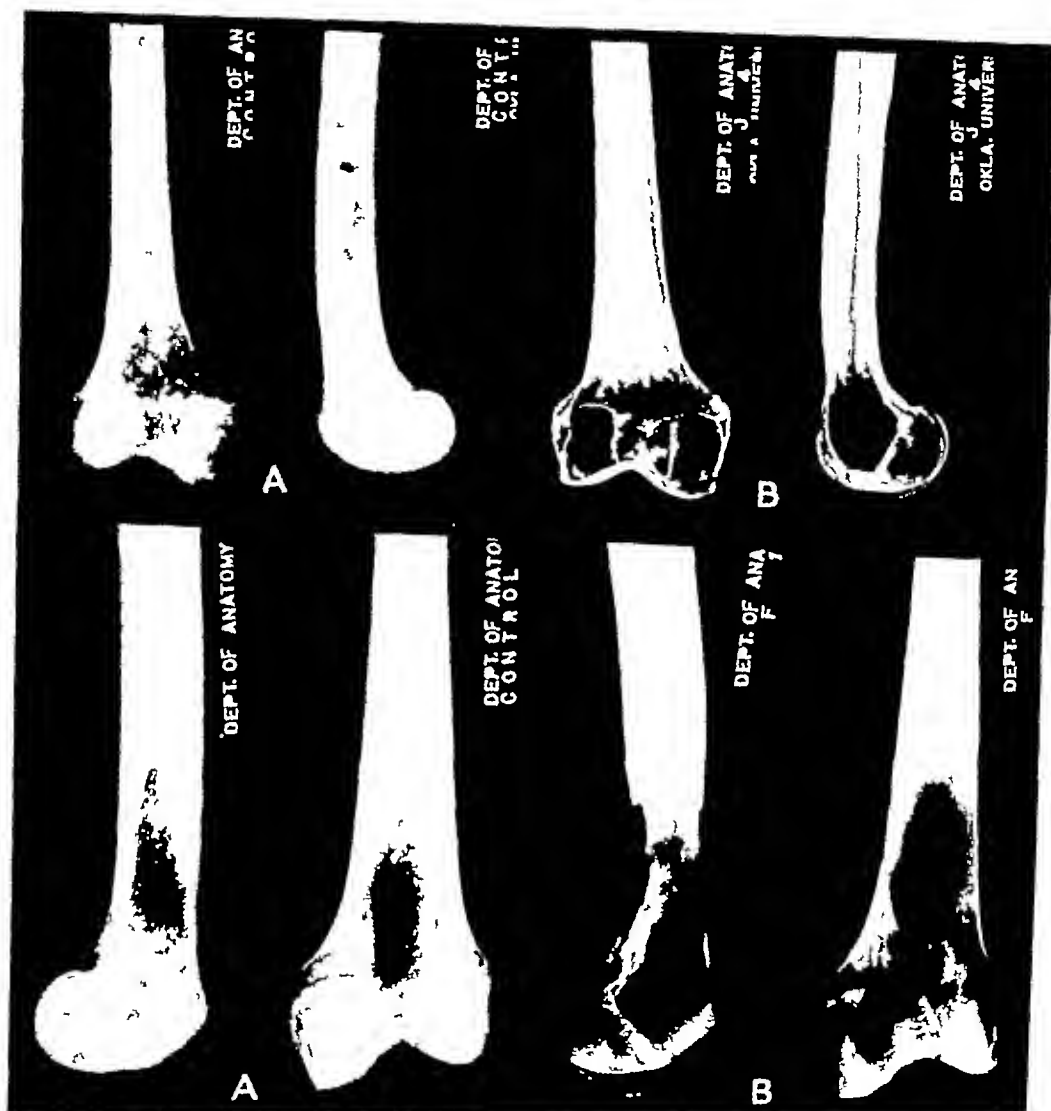


Fig 4-A (upper) Roentgenogram of the distal end of a normal macerated femur
 Fig 4-B The same bone has been split and the spongy part almost completely removed The exposure has been adjusted to the greater translucency of the bone
 Fig 5-A (lower) Roentgenogram of the distal end of a normal macerated femur
 Fig 5-B The same bone with artificially produced circumscribed defects involving the cortex only

spongy layer It is to be noted that the diameter of the cortex gradually decreases toward the knee joint and the spongy layer gains in extent From these facts we may come to the conclusion that the share of the two elements of bony structure in the roentgenogram changes at different levels Further proof can be obtained from other experiments² Figure 3-1

² In a previously published group of experiments (Lachmann and Whelan 1936) we attempted to ap

proach the problem by the following consideration If we decalcify two bones of the same type one from the outside the other from the inside—in this case protecting the outside by a coat of paraffin—and determine the amount of calcium removed by chemical analysis the result would show up the relative significance of each part In the event that we obtain positive results by destruction of the spongy part with less decalcification than by dissolving the cortex we can say that the spongy layer is more important for the picture than the cortex and vice versa This arrangement while fitted for smaller bones like the carpals and tarsals was not satisfactory for the long bones which are the object of our study in this paper

shows the distal end of a normal macerated femur in front and profile views. Figure 3-B shows the same bone with the cortex almost completely removed in the condylar and supracondylar part. The exposure has been adjusted to the greater translucency of the bone. If the last illustration is compared with the control, it is surprising how few are the changes, although the cortex is almost completely absent in the lower part of the bone. We notice slight alterations in the contours. The details of the spongy pattern stand out more distinctly. Certain lines in the condylar area are absent.

If, on the other hand, the spongy layer is removed, we encounter a great difference. Figure 4-A shows a normal bone in both views. In Figure 4-B the bone has been split and the spongy part almost completely removed. The exposure has been adjusted to the greater translucency of the bone. The increased translucency varies in extent with the thickness of the cortex and is especially noticeable in the condylar and epicondylar area. While the contours of the bone are preserved, the structural pattern has almost completely disappeared. We notice also that certain lines visible within the bone on front view now stand out distinctly, they are, therefore, of cortical origin and represent the outlines of the condyles, seen on edge. Foramina nutritia, which on the control hardly could be differentiated from intertrabecular spaces, can now be made out in the supracondylar area on the front view. Attention will be drawn to a markedly translucent area on profile view, present above the condyles and which gradually fades toward the diaphyseal region of the bone. Its base at the level of the roof of the intercondylar fossa is represented by a dense line running from above and posterior to below and anterior. It is called "Ludloff's spot," and will be discussed later.

By comparing Figures 3-B and 4-B we obtain an idea of the share each structure has in the production of the roentgenograph. If we imagine the cortex-free bone in Fig-

ure 3-B sunk into the spongy-free bone in Figure 4-B, we have a complete conception of the formation of the roentgenograph. We now understand that, in addition to the outline of the bone on the x-ray film, certain lines within the bone also are produced by cortical layers which are met on edge by the x-ray beam, while the structural pattern and the general opacity in the region discussed are due mainly to the spongy part. We view this trabecular arrangement as through a milky glass of different opacity, the intensity of which is determined by the thickness of the two layers of cortex parallel to the x-ray film.

From the facts discussed we come to several reservations which are the cause of a like number of diagnostic difficulties. Cortical, as well as spongy, structures are responsible for the absorption of x-rays and for the casting of the shadow on the film. Their respective shares depend on their relative thickness and will, therefore, vary in different regions. Thus increased translucency of bony substance, as we find it in atrophy, may be produced by disappearance of part of the cortical or spongy matter or by involvement of both. To determine decalcification as to the bony layers affected we must take into account the site of atrophy. Observation of the cortex where it is seen on edge will also help. Of importance, as well, is the fact that even in places where the cortex plays a relatively unimportant part, localized destruction of it, especially if not combined with general thinning of the cortex around the defect, will be recognized more easily than generalized removal of the cortex, due to the increased contrast between defect and surrounding areas. In Figure 5-B we have artificially produced a number of localized defects involving only the cortex. They are distinctly visible (Figure 5-A is the same bone untreated). The foramina nutritia within the cortex are examples of normal cortical deficiencies which may be mistaken for pathologic destruction.

Identification of certain lines within the bone has often produced controversial



Fig 6-A (left) Roentgenogram of the proximal two-thirds of a normal macerated femur shaft
 Fig 6-B The same bone with the spongy portion removed completely
 Fig 7-A (center) Roentgenogram of the head and neck of a normal macerated femur
 Fig 7-B Roentgenogram of a thin section of the same bone
 Fig 8-A (right) Roentgenogram of the distal end of a normal macerated femur Medial condyle to the right lateral to the left

discussion If they are visible within the silhouette on both views, we are inclined to localize them in the spongy layer, although they really may be part of the cortex seen on edge This is especially the case in bony parts which have as complicated form as the distal end of the femur While a certain oblique line in the cortex-free bone in Figure 3-B (which is probably due to old rickets), is certainly localized in the spongy layer, other lines farther down in the condylar area are of cortical origin as is shown in the spongy-free bone in Figure 4-B The analysis of Ludloff's spot will illustrate this further

Each area has to be judged according to its own merits Figure 6-A shows the proximal two-thirds of the normal femur shaft below the intertrochanteric region Figure 6-B is the same bone with the spongy portion removed completely In the relation of thick cortex to small amount of spongy layer we see the reason for the almost identical appearance of the two roentgenograms (compare with cross-sections 1, 2, and 3 of Figure 2) A destructive lesion involving only the spongy layer in this area would not show up at all on the x-ray film

Since the importance of the spongy structure has been emphasized sufficiently, it is also necessary to keep in mind that

the spongy pattern which we see on the roentgenogram does not correspond to individual layers of bone trabeculae, but that it represents a superposition of many strata of spongy bone which lie in the plane of the x-ray beam The roentgenographic image of the bony meshwork is produced by a summation effect (Francke) By a very ingenious arrangement Francke has shown that two femora, which are superimposed on an x-ray film, may cast exactly the same shadow as one, in the same way as an x-ray film of a thin section of bone may be almost identical with that of the whole bone (taken, of course, under different conditions of exposure) Figures 7-A and 7-B, in which A is the roentgenogram of the head and neck of a complete femur, and B of a thin section of the same bone, illustrate this Thus it becomes clear that destructive foci within the spongy bone must attain a certain size in order to become visible on the roentgenogram Many other factors are also involved, for instance, the relative and absolute thickness of the two layers composing bone, the density of the structures surrounding the defect, and the quality of the x-ray beam From the facts presented we arrive at a clearer understanding of the limitations of the x-ray method

A detailed analysis of the roentgeno-

gram of the knee joint requires a separate study of the standard projections. Many of the important facts can be gained by stereoradiography and by comparison of object and x-ray film, while the semi-translucent Spalteholz specimens are especially helpful. These facts are enumerated in the literature quoted above. Other important points of practical interest become evident only by use of serial sections, a method which has been described above. They will now be discussed.³

DISTAL END OF FEMUR (FRONT VIEW)

Direction of the x-ray beam postero-anterior

A roentgenogram of a normal femur (Fig 8-A) in this projection shows the lateral condyle to be less translucent than the medial, a fact explained by the arrangement of the trabeculae as shown on cross-sections of the femur (Fig 2, sections 6-9). It is not so much the greater density, which has been pointed out by Krause and which has been given as the reason in the literature (Hulten), although this may also play a part, but rather the direction of the trabeculae in relation to the x-ray beam. Only in the case of the lateral condyle do they run almost in the same plane as the x-rays. The importance of this normal difference in translucency of the condyles can be gathered from the following quotation from Kohler

"Tuberculosis has frequently its site in one of the femoral condyles. The first changes occur in the bone, but do not catch the eye immediately in the roentgen picture, they occur, not in the form of foci, but more in the form of a diffuse translucency of the affected condyle easily recognizable as such."

Thus the normally greater transradiancy of the medial condyle may be mistaken for tuberculosis. Other things being equal, atrophy will be more marked also on the medial side. Hulten and

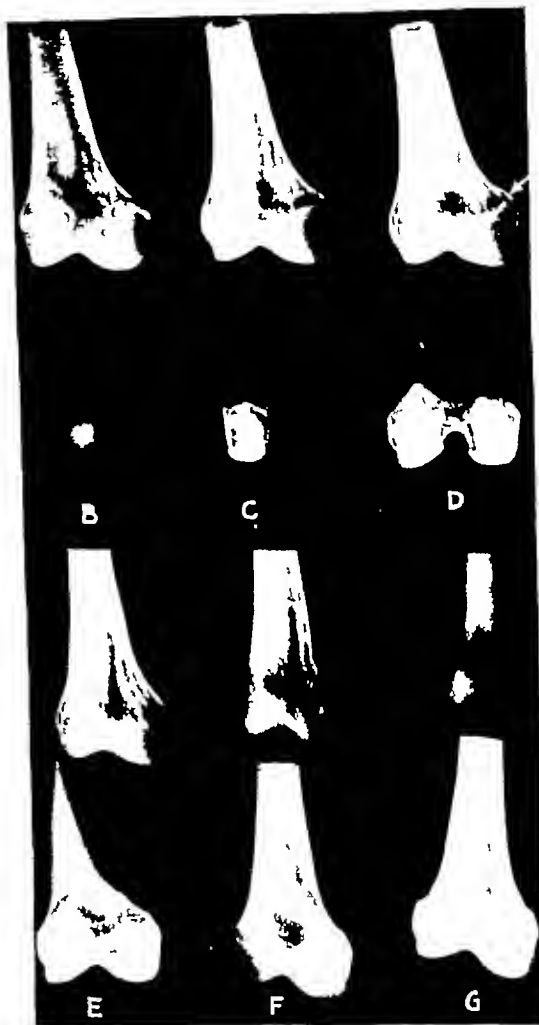


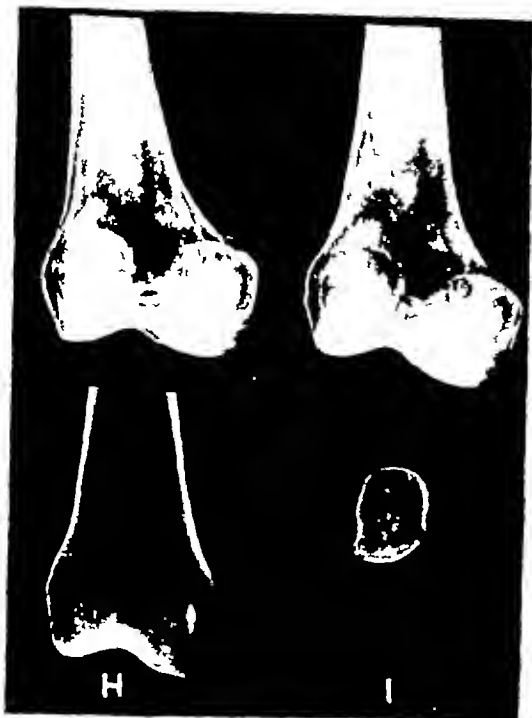
Fig 8-B to D (upper) Roentgenograms of the same femur as in the control Figure 8-A. The bone has been cut in 11 serial sections in frontal plane (compare Fig 1-B). In each consecutive roentgenogram one or more sections have been removed. The removed parts are always shown underneath. In Figure 8-B a fragment of 5 mm thickness is taken from the posterior surface of the medial condyle. In C the whole medial condyle is removed. In D both condyles with part of the bone around the intercondyloid fossa. Medial condyle to the right, lateral to the left. Arrow at the adductor tubercle on D.

Fig 8-E to G (lower) See caption for Figures 8-B to D. In E the bone has been divided into a larger anterior and a smaller posterior portion, which includes the condyles. F shows the bone divided in a smaller anterior and a larger posterior portion. In G only a thin part of the anterior cortex with some spongy structure is left.

³ A structural analysis of the femur on a mechanical and mathematical basis, for which roentgenograms are very helpful, is not within the scope of this paper. In this respect reference is made to the investigations by Wolff, Gallios and Bosquette, Gebhardt, and Koch.

Schunz reports that the difference in density between the lateral and medial condyles is more pronounced in genu valgum.

Figures 8-B to 8-G show roentgenograms



Figs 8-H and 8-I Roentgenograms of the same femur as in the control Figure 8-A. In *H* a fragment from inside the bone has been taken out, containing mostly trabecular structure. In *I*, a section from inside the lateral condyle. Medial condyle to the right, lateral to the left.

F of the same femur as the control film, 8-A. The bone has been cut in 11 serial sections (5-8 mm thick) in frontal plane. In each consecutive roentgenogram one additional section has been removed.⁴ The removed parts are always shown underneath. In Figure 8-B, a fragment of 5 mm thickness is taken from the posterior surface of the medial condyle, in *C*, the whole medial condyle is removed, in *D*, both condyles with part of the bone around the intercondylar fossa. In *E* the bone has been divided into a larger anterior and a smaller posterior portion, which includes the condyles, *F* shows the bone divided in smaller anterior and a larger posterior portion, and in *G* only a thin part of the anterior cortex with some spongy structure is left.

Thus a detailed analysis of the x-ray

⁴ A number of roentgenograms of intervening sections are not shown here.

pattern of the femur is made possible and every line on the film can be localized as to its anatomical substrate. Figure 8-B demonstrates the share of a thin cortico-spongy layer in the production of the general opacity of the picture, in *C* we observe that the distinct lines in the roentgenogram of the condylar area are produced by the contour of the condyles seen on edge. Figures *C* and *D* also prove that the x-ray pattern is the expression of a summation effect of different layers of spongy structure, since the arrangement of the trabeculae is undisturbed, although a considerable part of trabecular structure has been removed. In Figure *E* an area of condensation within the spongy structure, a so-called "compact island," which is hardly visible on the control, now appears very distinctly. Thus we may assume that these compact islands are more frequent than we would expect from the study of roentgenograms. We found them in our sections in several cases.

An irregularity on the lateral side of the lateral condyle is easily discerned as corresponding to the groove for the tendon of the popliteus muscle, as can be recognized from the fragments in Figures 8-D and 8-E below.⁵ It should not be mistaken for an arthritic change. The same holds true for the adductor tubercle which is visible above the medial condyle (arrow on Figure 8-D). Other irregularities in the contours of the condyles may be due to the insertion of the collateral ligaments.

In Figure 8-G with only a very thin layer of mostly cortical bone remaining, we see the numerous foramina nutritia as small defects which now can also be identified on the control, although much more indistinct.

As was to be expected from what had been said before, this thin layer of bone has no influence on the pattern. The picture in Figure 8-G, below, is almost identical with the control. The influence of single slices of bone in the roentgenogram becomes

⁵ In reality there are several grooves for the tendon in the positions of extreme flexion, moderate flexion, and extension, as H. Virchow has shown (quoted from Krause).

clearest if we remove just one layer of bone and roentgenograph the rest. While Figure 8-G illustrates the influence of a thin cortical slice which lies parallel to the x-ray film, Figure 8-H illustrates that of a fragment from inside the bone which contains only trabecular structure (except for a thin shell of cortex which is in line with other parts of the cortex seen on edge). No distinct change is produced if we disregard the disappearance of the compact island. In Figure 8-I a bony fragment of about 5 mm thickness, consisting of spongy structure and a thin cortical layer which runs in different directions to the x-ray beam, has been removed from inside the lateral condyle. We see no change in the translucency of the bone. The lateral condyle still is more opaque than the medial. Where the cortex of the fragment participated in the formation of the condylar contour we see disappearance of those lines. In other areas where the cortex was arranged in a plane oblique to the x-ray beam, as in the upper medial corner of the lateral condyle, we notice a distinct defect.

DISTAL END OF FEMUR (PROFILE VIEW)

Direction of the x-ray beam medio/lateral

The analysis of the profile view of the femur undertaken again by serial sections in planes vertical to the x-ray beam leads us to a discussion of Ludloff's spot. This is a translucent area which appears on lateral view of the normal femur in the anterior portion of the condylar region (Figs 9-A, 9-B, and 10-A). It is approximately triangular in children, while in adults its upper contour is indefinite. Here it gradually passes over into the more translucent central region of the diaphysis. Ludloff, after whom this area is named, was the first to point out that it is absolutely normal and should not be mistaken for any destructive focus, for instance, tuberculosis (Ludloff, Köhler). Referring to Ludloff's paper, Köhler gives the following definition of this area:

"This epiphyseal spot is quite a normal appearance, it shows in the interior a fine net-

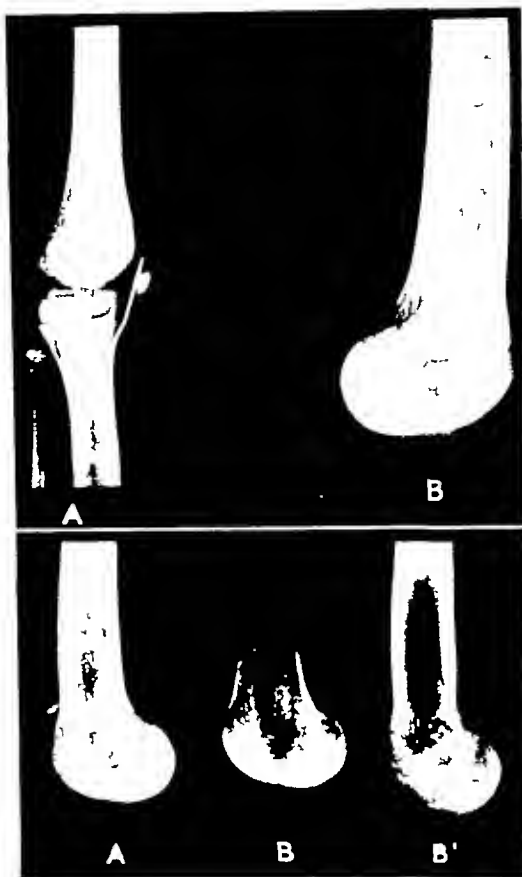


Fig 9-A (upper) Lateral view of a knee joint, patient aged 5

Fig 9-B Lateral view of a femur, patient aged 10. Both roentgenograms show Ludloff's spot

Fig 10 (lower) Analysis of Ludloff's spot by section method

Fig 10-A Lateral view of the distal end of a normal macerated femur

Fig 10-B Slides containing the medial condyle and the intercondylar area have been removed. B' shows the removed fragments. Distal contour of Ludloff's spot has disappeared in B

work of bony trabeculae and is not sharply delimited by a single line, but by the trabeculae running to its edge being denser. It is said to correspond to the place in both condyles where numerous nutrient vessels enter the condyle and where the reflexion of the synovialis is situated. It appears most prominently about the sixteenth year. Thereafter it passes without any definite dividing line into the transparency of the interior of the diaphysis. Its distal anterior and posterior contour correspond to the corticalis of the femur between the two condyles."

Grashey describes the translucent epiphyseal spot as framed in its distal portion by a plug-shaped zone of denser osseous



Fig 11 Roentgenogram of three sagittal sections of macerated femur, put together two adjacent ones representing two peripheral sections from medial condyle and a third of about 7 mm thickness corresponding to the center of the intracondylar area. Slices are arranged according to their natural position in the complete bone. Distal contour of Ludloff's spot is visible.

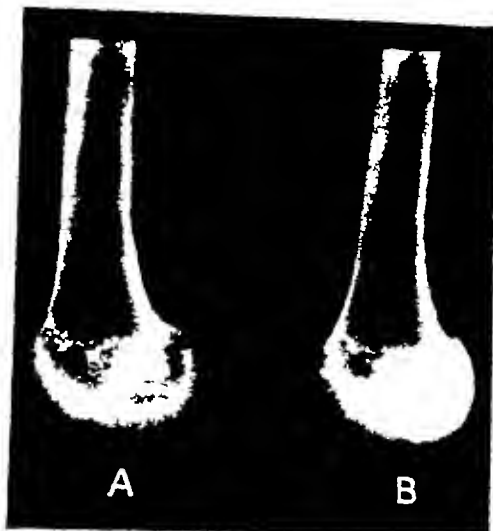


Fig 12 A Lateral view of a normal macerated femur, showing Ludloff's spot.

Fig 12 B A narrow cortical zone of about 1 cm in width has been filed away all around the distal end of the bone. The distal contour of Ludloff's spot has almost completely disappeared.

tissue "This plug corresponds, partly at least, to the bony bridge between the two condyles."

In analyzing the area in question we have to distinguish between its dense contours and its translucent interior. As to the contours the definition by Kohler is somewhat inconsistent. On one hand we learn that the spot is not sharply delimited by a single line but by the trabeculae on its edge being denser, on the other that its distal anterior and posterior contours, which are the only contours we can make out in the adult, correspond to the cortices of the femur between the two condyles.

We used a number of methods to solve this problem. From Figures 9-A and 9-B it is clear that the proximal boundary of the area in children is the epiphyseal line and correspondingly in an adult bone (Fig 10-A) we see the old epiphyseal scar going through the region as a faint, indistinct line. The analysis with our section method shows that the distal contour of the spot disappears when the slices containing the intracondylar cortex are removed. Figure 10-B demonstrates this

(B' shows the removed fragments). This investigation was supplemented by the following arrangement. Only three slices of another bone were roentgenographed, two adjacent ones representing the two peripheral sections from the medial condyle and a third of about 7 mm thickness which corresponds to the center of the intracondylar area. The slices were arranged according to their natural position in the complete bone. Figure 11 shows the roentgenogram. We see the lines corresponding to the distal contour of Ludloff's spot produced by a cortical zone of not more than 7 mm in thickness. Thus we realize that it is not the whole intracondylar cortex which bounds Ludloff's area, but just that central part which lies exactly in the direction of the x-ray beam, while the adjacent sloping portions play only a small part in producing this distinct demarcation.

To obtain the final proof, we filed away a small cortical zone about one centimeter in width all around the distal end of another femur in the intracondylar plane. The result is shown in Figure 12-B, 12-A depicts the same bone untreated. We see

that the distal contour of Ludloff's spot has almost completely disappeared. The epiphyseal scar is visible as an indistinct line interrupting the translucency.

Ludloff stresses especially the fact that

dyles and in the intracondylar field. While this may be true to a certain extent, the roentgenograms of our spongy-free bone (Fig 4-B) demonstrate beyond doubt that it is not the arrangement of the trabeculae

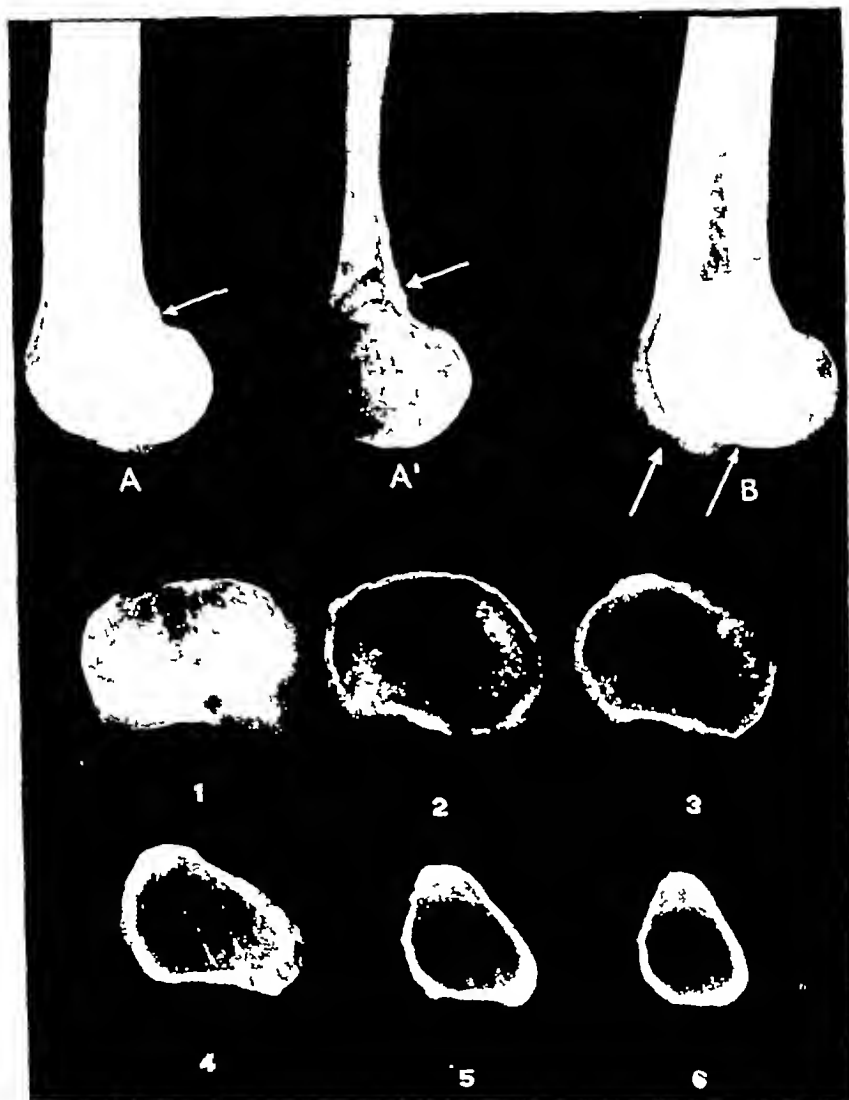


Fig 13 (upper) Profile view of the lateral (A) and medial portion (A') of the distal end of a macerated femur showing the origins of the lateral and medial head of the gastrocnemius muscle as distinct protrusions on both fragments in the region of the planum popliteum (arrows on A and A')

Fig 13 B Depicts the limiting grooves, mentioned in the text, on both condyles (arrows on 13-B)

Fig 14 (lower) Roentgenograms of horizontal sections through upper epiphysis and proximal part of shaft of tibia.

the increased transparency of the interior of this region is produced by superimposed areas of greater sponginess in both con-

which is the cause of the increased transparency, but the change in thickness of the cortex. In judging the translucency

of an area we do not use any absolute measurements, but compare it with the relative density of the surroundings. In our case we compare it with the density of the condylar region, which is brought about by four layers of cortex, and of the distal end of the shaft, the cortex of which gradually increases in thickness toward the femoral head (compare horizontal sections Fig 2). Finally we see that the lateral view of the cortex-free bone (Fig 3-B) shows no trace of Ludloff's spot.

Summarizing our findings in this respect we state that the distal anterior and posterior contours of Ludloff's spot are formed by a narrow zone of intracondylar cortex and that the increased transparency of the region is produced by the change in the diameter of the cortex which is especially thin in the area in question.

Some other points in the analysis of the profile view of the femur which are of practical importance will be discussed. Often we notice on the posterior contour of the femur, in the area of the planum popliteum, a pointed process which may be mistaken easily for an arthritic spur. It is normal, although it may be enlarged in arthritis (Kohler), and corresponds not so much to the insertion of the adductor magnus (Grashey), which is farther in front, but to the origin of the medial or lateral head of the gastrocnemius or of the plantaris muscle, if lateral. That it may depict a roughness of the planum medially or laterally is proven by Figures 13-A and A', where the process is visible on the sections comprising the lateral (A) as well as the medial (A') part of the bone (arrow on A and A').

Attention may be directed also to a misleading irregularity of the inferior articular surface of the condyles where it passes into the anterior articular plane. It corresponds to a limiting groove on the inferior surface of the condyles which is produced by the anterior border of the tibia at the site where it reaches the femur in the position of extreme extension. According to Mikulicz and Krause it is more pronounced on the medial condyle. Figure

13-B which projects the femur in an oblique position after part of the medial condyle has been removed, shows the limiting grooves on both condyles, much more distinct on the lower and medial than on the lateral (marked by arrows). As Hulten points out, these grooves may appear also on anteroposterior view and may then lead to the wrong diagnosis of an arthritic change. Like all normal anatomical irregularities these grooves become more marked with increasing age (Hulten).

TIBIA (PROXIMAL END)

A study of cross-sections through the proximal end of the tibia furnishes us with an understanding of the share of the cortical and spongy structures in the production of the roentgenogram. In Figure 14, which depicts horizontal sections through the condylar region and the proximal part of the shaft, we notice the same relations in the amount of cortical and cancellous tissue as we found in the distal end of the femur. The closer to the joint, the thinner becomes the cortex and the larger the share of the spongy tissue (Fig 14, sections 1 and 2), while in sections 3 to 6 through the shaft at the level of the tuberositas tibiae the cortex has increased in diameter and the trabeculae are arranged in loose tracts according to the lines of internal stress. We may conclude that here also—analogueous to the femur—the importance of the two structures changes with the level of the bone. Therefore that which has been said in the first part of this paper in this respect regarding the femur, holds true also for the tibia.

PROXIMAL END OF TIBIA (FRONT VIEW)

Direction of the x-ray beam anteroposterior.

In Figure 14, sections 3-6, we observe that spaces are left between the trabecular columns where we find no, or very few bony laminae. This gives us an explanation for the presence in the roentgenogram of areas "poor in lime about the size of peas which one sometimes meets directly underneath the intercondylar tubercles."

(Kohler) See the normal control, Figure 15-A Foramina nutritia, which are numerous in this region and which are disappearance of the upper curved contour of the articular surface of the medial condyle This curved line, therefore, cor-

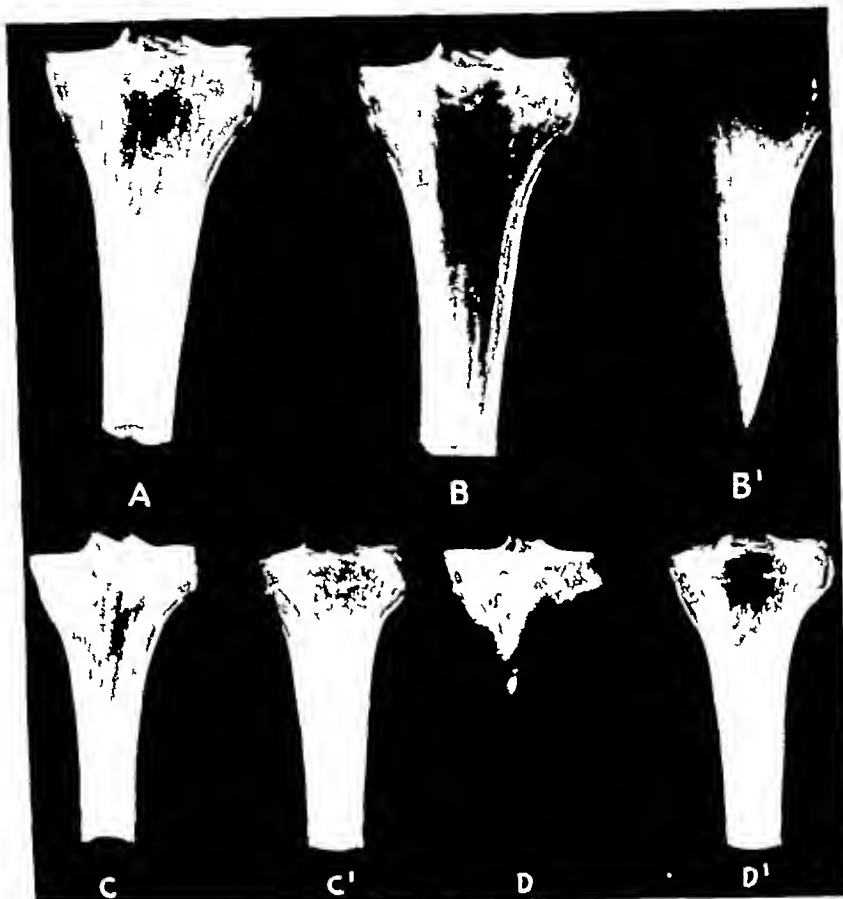


Fig 15 (*upper*) Serial sections through proximal end of tibia Medial condyle to the left lateral to the right

Fig 15-A is the normal control In Figure 15-B a thin section from the anterior surface of the bone has been removed B' shows the removed portion

Fig 15-C (*lower*) shows the same bone as in Figure 15-A divided into a posterior (C) and an anterior half (C') In Figure 15-D only one section from the posterior surface of the bone has been left, Figure 15-D' depicts the removed portions

visible on our first frontal section (Fig 15-B'), may add to the spotted translucency On horizontal sections (Fig 14, 3-6), we notice a pronounced cortical protrusion corresponding to the tuberositas tibiae On anteroposterior view this appears as an ill-defined density of the shaft below the epiphysis, lateral to the middle line (Fig 15-B') The roentgenogram in Figure 15-C still resembles the control very much, although more than half of the thickness of the bone has been removed We notice

responds to the anterior border of the joint surface, while the straight line, as Figure 15-D shows, represents the posterior border, not the floor of the condyle, as Grashey describes it This last view and others, which are not shown here, also demonstrate that the roentgenogram of the intercondylar tubercles is produced by a summation of structures which lie in different frontal planes The roentgenogram of the medial tubercle corresponds to a bony protrusion which lies on a more

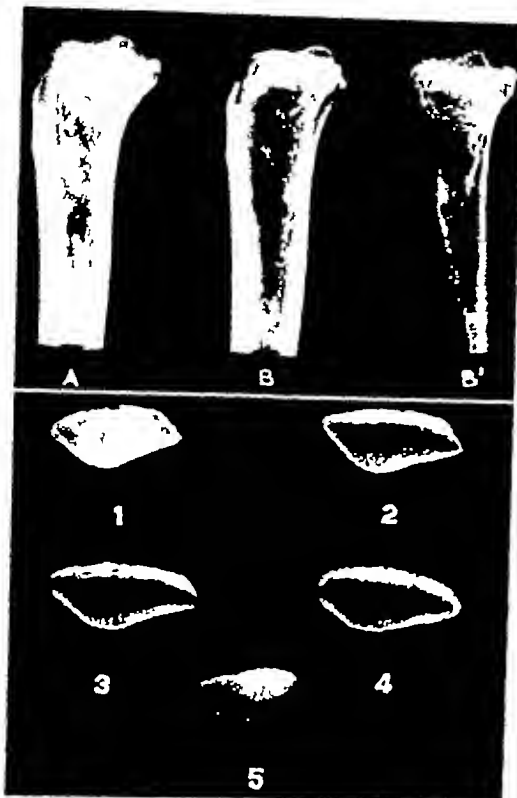


Fig 16-4 (upper) Profile view of the proximal end of a normal macerated tibia. In Fig 16-B the bone has been divided into a lateral (B) and a medial (B') portion.

Fig 17 (lower) Roentgenograms of horizontal sections through the patella.

posterior plane than the one which is responsible for the view of the lateral. The postero-inferior border of the posterior intercondyloid fossa is delineated by an indistinct U-shaped line which is best visible in Figure 15-D, but which can be recognized also on other views.

PROXIMAL END OF TIBIA (PROFILE VIEW)

Direction of the x-ray beam tibio-fibular.

The profile view of the tibia does not contain many features which require special study and explanation. In our lateral view of the tibia (normal control Fig 16-A), we see three nearly horizontal lines connecting the anterior and posterior borders of the bone in the condylar region corresponding to the articular surface. One of our sections, which divides the bone into nearly equal lateral and medial halves

(Figs 16-B and 16-B'), demonstrates the anatomical substrate of these lines. The sharpest line in the roentgenogram, Figure 16-B, which depicts the lateral half, represents the lateral infraglenoid margin of the tibia. In Figure 16-B', showing the medial half of the tibia, we see two lines, an upper, interrupted by the medial intercondyloid tubercle, and a lower. The upper corresponds, as detailed comparison between bone sections and other roentgenograms (not shown here) prove, to the medial part of the condylar articular surface, the lower to the medial infraglenoid margin. All three lines are visible also on the control. As to the intercondyloid tubercles, we see from our figures that one is superimposed on the other. Detailed analysis shows that only their posterior contour produces partly separate delineation.

PATELLA

Horizontal sections at different levels demonstrate a thick anterior and a thinner posterior cortex which meet at the sides (Fig 17). Enclosed in this shell of cortical substance is a trabecular meshwork, the individual tracts of which run mostly in an anteroposterior direction. Sections in sagittal planes confirm this (Fig 18) and show that the anterior cortex is made up of densely arranged cephalo-caudad running trabeculae (Joachimsthal). From these facts we recognize that a full face view of the patella (even if it is possible to obtain it free from the overlapping femur through oblique projection) will not yield much information in regard to the structure of the bone. The proportionally thick anterior cortex will, curtain-like, obscure many structural details. Roentgenograms of our frontal sections (Fig 19) confirm this. Since the spongy structure is presented as a summation picture we can remove layers of bone without obtaining any change in the spongy arrangement. In Figure 19 comparison of the roentgenogram of the anterior half of the patella (B) with the roentgenogram of the posterior half (B') shows the former more

opaque than the latter due to the thickness of the anterior cortex. The spongy arrangement is alike in both views.

The lateral view will, therefore, give us more reliable information in regard to the spongy structure. Destructive foci involving the interior of the bone will show up on lateral view with greater probability since it is not obscured by a thick cortex. But here also the summation effect has to be taken into account. One fallacy should be pointed out. Since the trabecular arrangement normally is much looser in the apex of the bone, it should not be mistaken for a pathologic finding (Figs 18-A and 18-B). A slight angulation of the posterior surface of the bone, visible on lateral view, is normal and corresponds to a horizontal ridge which divides this area into a superior and an inferior zone for articulation with the lower and upper parts of the trochlea of the femur in flexion and extension (Joachimsthal).

JOINT FISSURE

Since narrowing or widening of the joint fissure on the roentgenogram has been used as a diagnostic sign, it is important to realize the limitations of this symptom. Popovic and Doric have noted variations in the width of the fissure due to change in position. In a series of examinations they found that the space on the average is at least 1.5 mm narrower in the upright than in the horizontal position. Swelling of the soft structures outside the joint will also lead to an apparent increase in the width of the joint fissure due to an increase in the distance of the object from the film. Direction of the x-ray beam, as well as the distance of the focus of the tube, from the film also plays a part.

Narrowing of the joint fissure on the injured side is supposed to be a sign of meniscus dislocation. In this respect a paper by Bauer is of interest. In a study of 150 knee joints he found in 58 per cent that the lateral part of the joint fissure was wider than the medial, in 14 per cent they were of equal width, while in 28 per

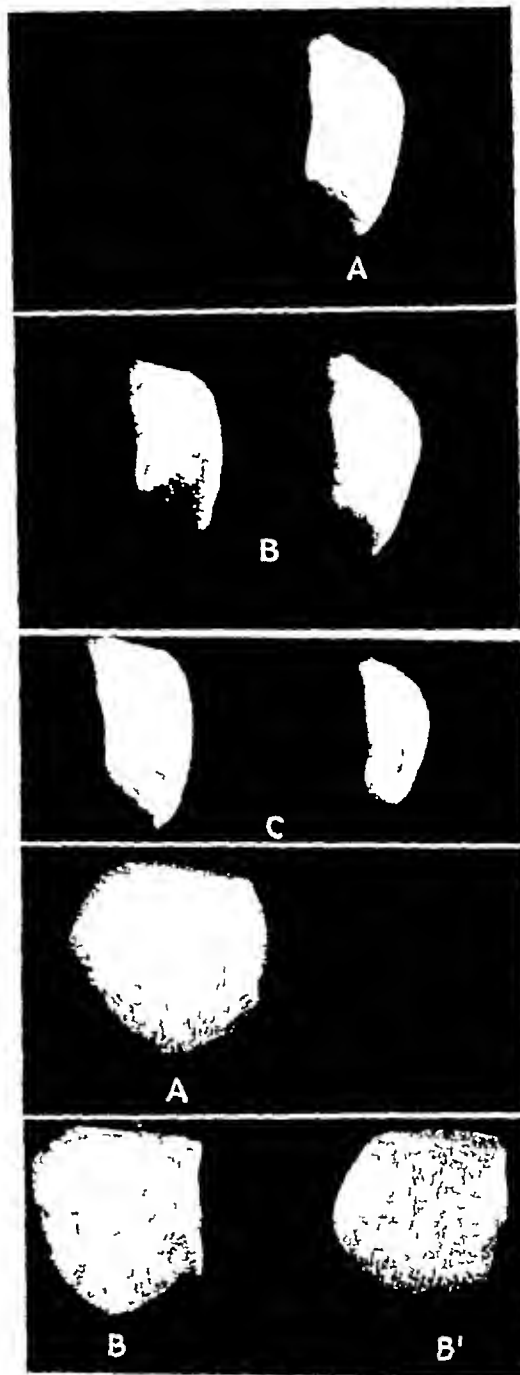


Fig 18 (upper) Roentgenograms of serial sections through a normal macerated patella. A Control. B and C depict sagittal sections through the same bone.

Fig 19 A (lower) Roentgenogram of a normal macerated patella.

Fig 19 B depicts the anterior half and B' the posterior half of the same patella.



Fig 20-A Profile view of the knee joint of an unembalmed cadaver

Fig 20-B The same knee joint after 40 c.c. of fluid have been injected. Note the increase in the distance between the two points connected by the line

cent the medial was wider than the lateral. These differences were always equally marked on both knee joints of the same individual, if they were not diseased. Bauer comes to the conclusion that the width of the joint fissure does not have great importance in the diagnosis of an injury to the meniscus.

Another diagnostic sign which has been made use of frequently in a suspected injury to a meniscus, is a slight displacement of a femoral condyle in a lateral direction. Köhler has pointed out that this incongruity may not be due to an injury, but may be a sign of constitutional variation which, however, disposes to arthritis.

Hulten has made extensive studies on the relation of the intercondylar tubercles of the tibia to the femur. He found numerous variations, but points out that in extension the medial tubercle is always lateral to the medial condyle of the femur within the intercondyloid fossa, and the lateral tubercle directly underneath the lateral condyle of the femur.

Widening of the joint fissure and an increase in the distance between the patella and the femur has been used as a sign for intra-articular exudates. Taking into account the above-mentioned reservations, the rising of the patella from its bed on the femur, as seen on profile view of the knee joint, may be of value in ascertaining the

presence of an exudate. In a group of experiments on unembalmed cadavers we tried to determine the amount of fluid necessary to produce a change in the position of the patella. While it may not be possible to come to definite conclusions with regard to inflammatory exudates *intra vitam* from our injection studies on cadavers, the results are nevertheless interesting. If we measured the distance between certain points on the patella and femur which can easily be identified, we found that an injection of an amount of fluid as small as 5 to 10 c.c. may produce a change in the distance of 0.1 cm, between these given points, injection of 20 c.c. increases the distance by 0.2 cm, 40 c.c. by 0.3 cm, 50 c.c. by 0.4 cm, 60 c.c. by 0.5 cm (Figs 20-A and B).

SUMMARY

1. A systematic analysis of the roentgenogram of the knee joint, which requires special technic, is presented.
2. The following experimental methods are used: chemical or mechanical removal of the cortical or spongy structures, serial sections of bones in planes perpendicular to the x-ray beam, production of small defects within cortex or trabecular structure or within both. Roentgenograms are taken at each stage of the different procedures.
3. The relative part of cortical and spongy layers in the production of the roentgenogram of the knee joint is demonstrated by various analytical experiments. Roentgenograms of the distal end of the femur are shown with either the cortical or the spongy part removed. Clinical implications in this connection are pointed out.
4. The spongy pattern in the roentgenogram does not correspond to single layers of bone trabeculae, but represents a superposition of many strata of spongy bone which lie in the plane of the x-ray beam.
5. A separate study of the roentgenogram of the standard projections is undertaken by serial sections. This leads to an inter-

pretation of a number of details in the roentgenograms, not mentioned, or explained differently in the literature

6 At variance with the literature are the findings in regard to Ludloff's spot, its distal anterior and posterior contours are formed by a narrow zone of intracondylar cortex and the increased transparency of the region is produced by the change in diameter of the cortex, especially thin in this region

7 Attention is drawn to a number of normal findings on the femur, tibia, and patella which are often misinterpreted as pathologic, *e g*, the popliteal groove on the lateral condyle of the femur, processes in the area of the planum popliteum corresponding to the origin of the two heads of the gastrocnemius and plantaris muscles, limiting grooves on the inferior surface of the femoral condyles, translucent spots in the proximal part of the tibia and in the apex of the patella

8 The limitations of the sign of narrowing or widening of the joint fissure in the roentgenogram are pointed out. In injection experiments on unembalmed cadavers with different amounts of fluid the rising of the patella from its bed on the femur is observed and measured on profile view

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A COMPARISON OF GASTROSCOPIC AND ROENTGEN FINDINGS¹

By RUDOLPH SCHINDLER, M D , and FREDERIC TEMPLETON, M D , Chicago

From the Department of Medicine and the Division of Roentgenology of the University of Chicago

THE flexible gastroscope has opened a new field in gastric diagnoses. In most cases it is safely and easily intro-

duced and allows excellent visualization of the gastric mucosa in the living person. We have had three gastric perforations, all occurring during the use of instruments equipped with the spherical sponge tip devised by Henning. Experimental evidence indicates that the friction of this tip was responsible for these non-fatal accidents (9). No accidents have occurred when the long-finger guide was used. Lesions obstructing the esophagus and cardiac end of the stomach, aortic aneurysm, and suspected esophageal varices are contraindications to gastroscopy.

Although most gastroscopists check their findings with roentgen findings, few radiologists check with the gastroscopist. Schatzki (8), Ansprenger (1), and Jutras (6) have made such comparisons. From 1926 to 1934 Sielman and Schindler made roentgenographic relief studies of the stomach in more than 4,000 cases. Of these cases, several hundred were gastroscopied. Since September, 1934, over 800 gastroscopies have been performed at the University of Chicago Clinics, most of these cases having been examined by Dr. Templeton by roentgen relief methods either before or after he had seen them gastroscopically.

Gastroscopic and roentgenologic examinations should be considered as co-operative rather than competitive examinations. Either method may visualize lesions that the other cannot. Shape, contour, motor function, and gross lesions are better seen roentgenologically, while mucosal changes and smaller lesions are better seen gastroscopically. In some cases the roentgenologic examination is sufficient for accurate diagnosis.



Fig 1 (above) Gastroscopic appearance of the normal posterior wall of the body. There are parallel folds, bifurcated folds, and cross folds.

Fig 2 (below) Gastroscopic appearance of the normal musculus sphincter antri and antrum. The twisted rope-like fold separates the corpus (below) from the antrum (above). The curved structure extending upward from the left end of the musculus sphincter antri is a part of the gastric angle and obscures the superior portion of the foldless antrum.

¹ Presented before the Radiological Society of North America at the Twenty-second Annual Meeting Cincinnati Nov 30-Dec 4 1936

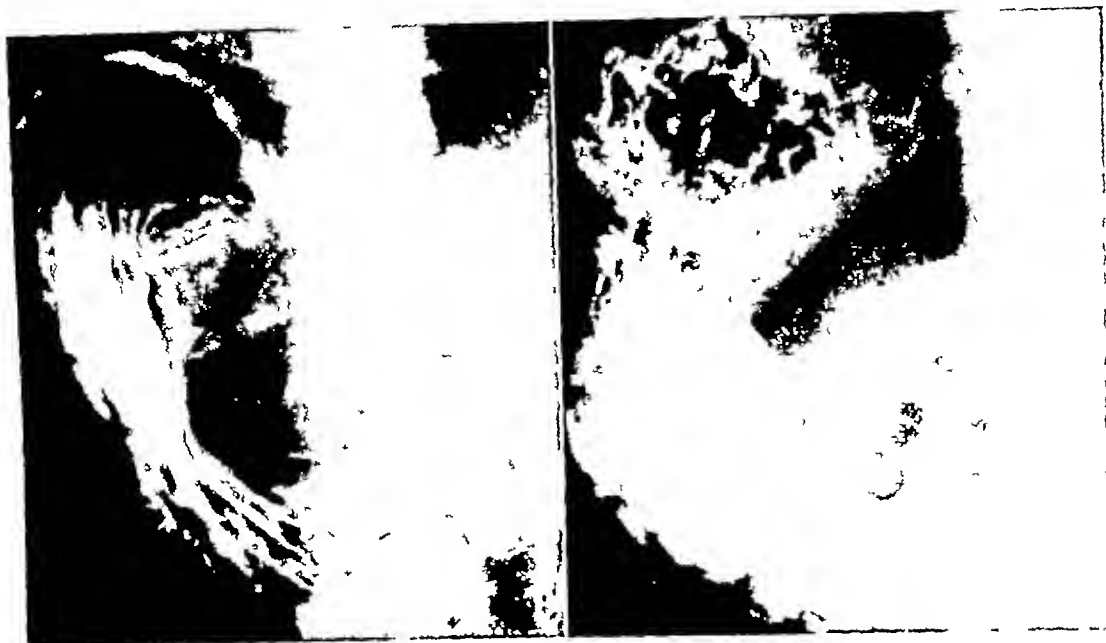


Fig 3

Fig 3 Normal gastric rugæ The folds tend to be parallel throughout the stomach and bulb At the angle note the characteristic crossing-over of the folds from the lesser to the greater curvature This appearance is presumably caused by a slight twisting of the antrum on the body

Fig 4

Fig 4 Normal gastric rugæ The folds tend to be wavy and occasionally branch The distance between the folds is quite wide

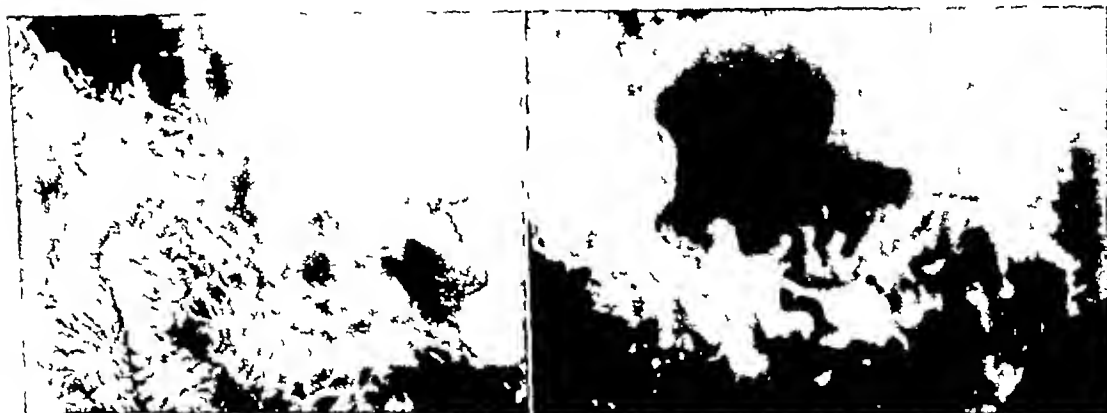


Fig 5

Fig 5 Normal gastric mucosa The polyp like folds may be mistaken for gastric polyps or hypertrophic gastritis Under the fluoroscope the folds were quite pliable and readily obliterated by pressure

Fig 6

Fig 6 Normal gastric rugæ The prominent antral folds resemble the ridges seen in crumpled paper (Gutzeit) At gastroscopy no antral folds were seen This stomach and those illustrated in Figures 3 4, and 5 appeared very similar at gastroscopy (See Figures 1 and 2)

GASTROSCOPIC APPEARANCE OF THE NORMAL STOMACH

In the normal stomach, differences between the gastroscopic and the roentgenographic appearance are quite striking Before the introduction of air the gastroscopist sees rather prominent, irregular,

parallel folds which apparently do not correspond with the rugæ This appearance of the collapsed mucosa presumably has nothing to do with its thickness and may or may not be of clinical significance On distention with air these folds flatten easily and there appear in the body from 10 to 14



Fig 7

Fig 7 Normal gastric rugæ in superficial gastritis. Four or five more or less parallel folds are seen in the body after a single swallow of barium mixture.



Fig 8

Fig 8 Same stomach illustrated in Figure 7 after more complete filling and the application of a slight amount of compression. A dozen or more folds are now seen. The folds have not enlarged but the spaces between them have diminished. Although superficial gastritis was present, similar appearances and changes have been observed in stomachs which were normal at gastroscopy.

parallel folds, many of which are irregular, bifurcated, and traversed by cross rugæ (Fig 1). Rugæ are rarely seen in the antrum, but a high-twisted cord-like structure separates the antrum from the body of the stomach. This fold, the musculus sphincter antri (Fig 2), usually cannot be identified with certainty at roentgenologic examination.

ROENTGEN-RAY APPEARANCE OF THE NORMAL STOMACH

(A) *After a single swallow of barium* — A variety of patterns may be seen (Figs 3-6). Not uncommonly there are from four to six roughly parallel folds in the body and the antrum, and occasionally the antrum contains in addition one or more oblique folds.

(B) *After filling the stomach with barium and then compressing it* — Now instead

of the four to six folds originally seen, there may be from 10 to 14 (Figs 7 and 8). Undoubtedly, the increase in number is to some extent explained by the entrance of barium into folds that were formerly pressed together or otherwise collapsed. Sometimes the parallel folds at the lesser curvature appear to split into pairs, while new folds appear as from nowhere. Several explanations have been suggested, but the fact is that many phases of the phenomenon are not understood.

CORRELATION BETWEEN ROENTGENOLOGIC AND GASTROSCOPIC APPEARANCES OF MU- COSA

In most cases the roentgenogram of the gastric mucosa bears little resemblance to the patterns seen by the gastroscopist, and sometimes changes clearly discernible at repeated gastroscopic examinations may be



Fig 9 Photomicrograph of a section through the gastric wall in a case of pernicious anemia. There is thinning of the mucosa with cellular infiltration and development of goblet cells. The submucosa is markedly increased in thickness.



Fig 10 Normal rugae in severe hypertrophic gastritis. The swollen rugae, erosions and small nodules seen between the folds at gastroscopic examination could not be demonstrated roentgenologically.

entirely undetectable by the roentgenologist. For example, there is the case of chronic ulcerative gastritis gastroscopied by Schindler in Munich on 65 occasions and followed over the same period by the roentgenologist, Sielman. During the period of observation Schindler noted the development of two sickle-shaped folds that crossed from the lesser to the greater curvature of the stomach and were interpreted as mucosal scars. Sielman, although convinced of the presence of the folds (on the basis of gastroscopic evidence), was unable to demonstrate the presence by any type of roentgen technic.

Conversely, the roentgenologist sometimes sees changes that are invisible to the

gastroscopist. A case of gastric lymphosarcoma reported by J. F. Renshaw (7) illustrates the point. Both methods showed folds that were large before treatment and decreased in size following it. To the gastroscopist, however, it seemed that regression continued until the mucosa became completely normal, while to the roentgenologist there was definite evidence of persistence of an abnormal pattern of folds radiating from a point on the lesser curvature of the stomach.

The frequent failure of the gastroscopist to see radiating folds of the sort so often seen roentgenologically in cases of gastric ulcer suggests that these folds are not true rugae but, instead, are wrinklins caused by changes in the submucosa or the muscularis. This may explain why roentgenologists sometimes see thickened folds in atrophic gastritis, a condition often marked by thickening of the submucosa beneath the atrophic mucosa (Fig 9).

Obviously, gastroscopy is best suited to the study of the mucosa, roentgenology to the study of the deeper gastric tissues.



Fig 11



Fig 12

Fig 11 Hypertrophic granular gastritis. At gastroscopic examination the folds appeared edematous and were covered with small nodules. At fluoroscopic examination the folds were rigid and could not be obliterated by pressure. Deep peristaltic waves progressed slowly through the entire stomach. The multiple small filling defects on the large folds in the central portion of the stomach are presumably caused by the small nodules seen at gastroscopic examination.

Fig 12 Large benign ulcer before treatment. The crater seems to be in the lesser curvature in this view taken with the patient prone. With the patient supine the ulcer appeared to lie in the posterior wall. The radiating folds so prominent in the film were not seen gastroscopically. Note the parallel rugae of the anterior wall superimposed upon the radiating posterior wall folds.

GASTRITIS

Chronic gastritis is by far the most common disease of the stomach, and its practical significance is still underestimated. The diagnosis of this condition depends almost entirely on the gastroscopist who has no difficulty in seeing the superficial granules, nodules, crevices, hemorrhages, ulcerations, and mucosal edema (10). Also, the small hemorrhages, pigment spots, and hemorrhagic erosions present in stomachs prone to development ulcers are quite apparent. These lesions rarely, if ever, are seen with present roentgenologic technics (Figs 7, 8, and 10). Schatzki (8), however, succeeded in demonstrating the erosions of ulcerative gastritis in one case.

In the past, many investigators believed that differences in fold thickness were diag-

nostic of inflammatory changes. Broad folds were assumed to be characteristic of hypertrophic gastritis, thin folds of atrophic gastritis. Experience has shown, however, that this conception was not entirely correct. Thick folds may be found in advanced atrophy and normal appearing folds in cases of hypertrophic gastritis. This bears out the finding of Henning who, as a result of his collaboration with Schatzki, found almost every type of fold in every form of gastritis (Table I).

Changes in fold thickness are not indicative of the state of the mucosa, and folds seen roentgenologically do not correspond to those seen gastroscopically or in the gross specimen. In certain cases, however, enormously enlarged folds which are difficult to obliterate with pressure are signifi-



Fig 13



Fig 14



Fig 15

Fig 13 Gastroscopic appearance of the ulcer shown in Figure 12. This large posterior wall ulcer illustrates the sharp edges indicative of benignity. The nodules in the floor are pancreatic lobuli. These lobuli probably caused the irregularity of the ulcer floor in the roentgenogram (Fig 12).

Fig 14 Gastroscopically the ulcer illustrated in Figures 12, 13, and 16 has reduced markedly in size after three weeks of treatment. There is some inflammation of the surrounding mucosa but the converging folds, observed roentgenologically, were not seen.

Fig 15 Gastroscopic appearance of the antral polyp illustrated in Figure 17. An umbilication, not an erosion, is present in the center of the polyp. Smooth mucosa suggests benignity but such cases should be examined frequently because of possible malignant changes.

cant. Such cases probably have associated changes in the submucosa and muscularis.

Chronic hypertrophic gastritis in three out of 450, or about 0.7 per cent of our cases, is characterized roentgenologically by the appearance of small nodular filling defects or thickened infiltrated folds (Fig 11). The fixed nature of these nodules produces a granular appearance that differentiates them from mucous flecks, small air bubbles, and food particles, all of which are free to move about under manipulation.

TABLE I—THE DIFFICULTY IN THE DIAGNOSES OF THE VARIOUS TYPES OF GASTRITIS FROM FOLD SIZE IS EMPHASIZED (From Henning)

Roentgen Reports	Gastroscopically Found
Broad folds	1 Hypertrophic gastritis
	2 Erosive gastritis
	3 Atrophic gastritis
	4 Normal picture
Normal folds	1 Normal mucosa
	2 Hypertrophic gastritis
	3 Atrophic gastritis
Small folds	1 Normal mucosa
	2 Atrophic gastritis

Cases have been described by Brunn and Pearl (3), Berg (2), Gutzeit (4), and Weltz (11). Roentgenologic differentiation from

submucosal infiltrating carcinoma, lymphosarcoma, and polyposis may be difficult. Deep, slowly progressing, peristaltic waves present in the three cases seen by us may be of differential diagnostic importance. On the other hand, some of the European investigators observed feeble peristalsis in this condition.

PEPTIC ULCER AND NEOPLASM

In most normal stomachs and most cases of pyloric neoplasm, the gastroscopist is able to see the pylorus, but quite commonly he cannot see this region in cases of duodenal ulcer or ulcer of the pyloric canal and pre-pyloric region. This is probably due to the fact that ulcerative lesions cause adhesions which displace the pylorus. An important diagnostic point is involved. If pyloric obstruction is present, the roentgenologist seldom has difficulty in demonstrating the fact, but he may be unable to differentiate between obstructing ulcer and neoplasm. In such cases, if the obstruction is malignant, the gastroscopist will probably be able to see into the pyloric antrum and observe the lesion directly. If he is not able to see into the pyloric antrum, this suggests that the pylorus is displaced by adhesions and, thus, speaks for a benign lesion.



Fig 16

Fig 16 After three weeks of medical treatment the ulcer illustrated in Figure 12 has completely disappeared. A few radiating folds remain but are almost completely obscured by the overlying prominent anterior wall folds.



Fig 17

Fig 17 Benign antral polyp. The rugae spread to enfold the filling defect caused by the polyp. The patch of barium at the center of the defect undoubtedly lies in the umbilication seen gastroscopically (Fig 15).

Ulcers along the lesser curvature of the antrum and occasionally in the body may not be seen by the gastroscopist even though they are readily seen by the roentgenologist. The ulcers along the lesser curvature of the antrum are often hidden behind the gastric angle (Fig 2), while the ulcers in the body may be obscured by the inflammatory edema about the margin, may lie behind overlapping folds, or may lie in one of the two blind spots, namely, a small area about the esophageal orifice and a small area on the greater curvature where the instrument impinges.

It is rare for the gastroscopist to find an ulcer missed at roentgen examination. Most of these ulcers occur high on the lesser curvature or posterior wall or in the stoma of an anastomosed stomach. Occasionally ulcers missed at routine roentgen examination can be demonstrated once the location

is known, others cannot be demonstrated regardless of the effort put forth.

The healing process of ulcers is usually best followed through the gastroscopist. In a case gastroscopied 13 times, the ulcer had not epithelialized after three months of therapy although the crater had disappeared roentgenologically (Figs 12, 13, 14, and 16).

Benign tumors, two centimeters or more in diameter, show well in relief roentgenograms (Figs 15 and 17). The smaller polyps, seen in 2 per cent of the gastroscopies, are often missed roentgenologically. This fact suggests that the soft early carcinomatous tumors may be seen earlier by gastroscopy than by relief methods. Actually, however, both methods have equal value as very early carcinomas may sometimes be seen by either method.

In carcinoma, gastroscopy has two advan-

tages It may be of greater value in determining the operability of a carcinoma as far as extent of involvement of the gastric wall is concerned and often permits definite differentiation between benign and malignant ulcer Because of the latter fact, gastroscopy is necessary in ulcers occurring in patients over 35 years of age

By means of gastroscopy carcinomas can be grouped into four morphological and clinical types Type I is the broad-based, polyp-like, well-limited tumor This is the type most amenable to resection Type II is an area of ulceration sharply limited from surrounding normal gastric wall This type, also, is susceptible to resection In roentgenograms it produces the well-known "meniscus" sign Type III is only partially limited and, therefore, operable only when it infiltrates toward the pylorus Type IV is a diffuse infiltrating carcinoma which, in its earlier stages may be overlooked by either of the two methods

Examination by the relief method should always be followed by examination of the barium-filled stomach Sole reliance upon the relief method may result in a diagnosis of an early carcinoma which does not exist Occasionally, gastric ulcers may not be seen or may be only suspected by relief

technic, whereas the filled stomach leaves no doubt of their existence

CONCLUSIONS

1 Roentgenograms and the gastro-scope should be looked upon as co-operative rather than competitive means of studying the gastric mucosa

2 Sometimes roentgenograms alone will establish the diagnoses but gastroscopy, as well, is often required

3 Some of the differences that occur between gastroscopic and roentgenologic examinations are described and explanations are offered as to why these exist

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THE VALUE OF GASTROSCOPY IN DIAGNOSIS¹

By EDWARD B. BENEDICT, M.D., *Boston, Mass.*

From the Massachusetts General Hospital

GASTROSCOPY was first attempted by Kussmaul in 1868, the subject of the experiment having been a professional sword swallower. A rigid in-

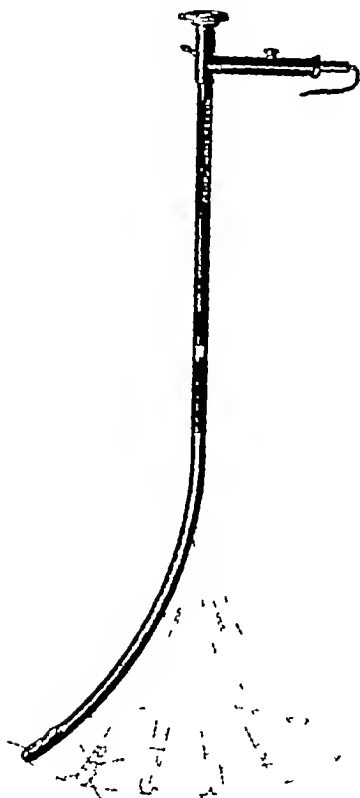


Fig. 1 The Wolf-Schindler flexible gastroscope

strument was used, the lighting was indirect, and no view of the stomach was obtained. Mickulicz, about 1881, again attempted gastroscopy with a rigid instrument, but the results were unsatisfactory. Since 1900 gastroscopy with rigid instruments has been practised in a few clinics,

principally in Germany, but most physicians have felt that for diagnostic purposes the results obtained did not justify the difficulties and dangers encountered in passing the instrument. The invention of the Wolf-Schindler flexible gastroscope (1) has made possible the frequent and general use of gastroscopy in diagnosis. The flexibility of this new instrument, invented by Dr. Schindler in 1932, has made the procedure relatively easy and safe. In a series of 400 gastroscopies performed at the Massachusetts General Hospital since 1933, I have had only one complication. This occurred in one of my early gastroscopies as a result of over-inflation of the stomach with air. A pin-point perforation followed, and a sterile pneumoperitoneum. Operative interference was unnecessary, but about ten days later, as the nitrogen in the peritoneal cavity had not been absorbed, it was released through a one-inch abdominal incision.

Gastroscopic examination is, of course, carried out with the stomach empty, codeine or morphine is given to aid relaxation, and atropine is used to diminish excessive salivation. Local analgesia of the throat is produced by the application of a solution of 2 per cent pantocain. The patient is placed on the left side of the examining table, with the head extended on pillows or held in the hands of a trained assistant. With the fingers of the left hand as a guide, the gastroscope is then introduced into the esophagus, and by very gentle pressure on into the stomach. A small amount of air is blown into the stomach through the sheath of the instrument, for without air space the walls of the stomach are collapsed and no satisfactory view is obtained. Orientation is accomplished by knowing the approximate depth of in-

¹ Read by invitation at the Twenty second Annual Meeting of the Radiological Society of North America in Cincinnati, Nov. 30-Dec. 4, 1936.

troductum, and by an indicator on the ocular which shows the direction toward which the objective lens is rotated

The chief value of gastroscopy is in the study of the finer changes in the gastric mucosa. X-ray examination is very accu-

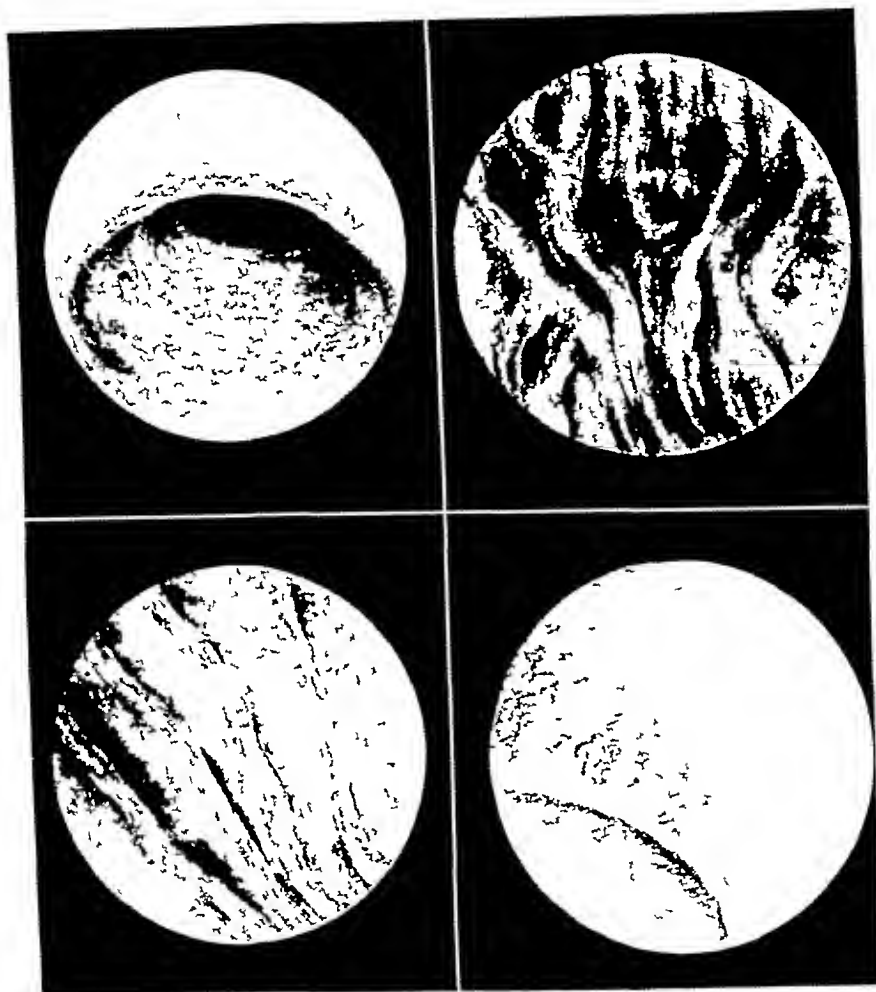


Fig 2 (upper left) Normal pylorus
 Fig 3 (upper right) Normal greater curvature Note normal rather large rugae
 Fig 4 (lower left) Normal lesser curvature Comparatively small rugae
 Fig 5 (lower right) Hypertrophic gastritis Typical verruccous appearance of the mucosa on the lesser curvature near the angle of the stomach

The appearance of the normal pylorus is shown in Figure 2. In the normal stomach regular peristaltic waves are seen passing over the antrum and ending with a tight closure of the pyloric sphincter. Rugae are usually not seen in the antrum by gastroscopy. The next drawing (Fig 3) shows the normal greater curvature where the rugae are quite large. On the lesser curvature rugae are small, as shown in Figure 4, or may be entirely absent.

rate in the diagnosis of peptic ulcer and neoplasm, and with the perfection of the relief method the roentgenologist is now studying the smaller lesions of the stomach. Here, however, the gastroscopist has the advantage of being able to look directly at the gastric mucosa and examine it in great detail in its natural color. Such gastroscopic study in no way lessens the necessity for x-ray examination, but is nevertheless an important additional diagnostic method.

Gastroscopy is of the greatest value in chronic gastritis (2), for in this disease the changes in the mucosa are smaller than in ulcer and cancer, and, therefore, are less easily recognized by x-ray examination. That chronic gastritis is a definite disease cannot be denied, for although the term has been loosely used in the past, we now have clinical, gastrosopic, roentgenologic, and pathologic evidence of its existence. Why, indeed, should anyone deny the existence of chronic gastritis, when in all other parts of the gastro-intestinal tract such diagnoses as stomatitis, esophagitis, duodenitis, enteritis, ileitis, colitis, and proctitis are generally accepted? The clinical diagnosis of chronic gastritis is unsatisfactory, for all investigators agree that the symptomatology is variable. Patients with chronic gastritis may have symptoms suggestive of ulcer, carcinoma, or neurosis. Gas, fullness, anorexia, heartburn, epigastric distress or pain, nausea, vomiting, and hematemesis may all occur in patients with negative x-ray examination. In some of these patients x-ray study may suggest gastritis, in many of them gastroscopy will demonstrate chronic gastritis. Dr Schatzki in his presentation will give the x-ray evidence of chronic gastritis, while the gastrosopic appearance of gastritis will follow shortly in this paper. Pathologically, gastritis is diagnosed by edema, leukocytic infiltration, increase in the number and size of the lymph follicles, degeneration of the glandular epithelium, and erosions of the mucous membrane.

The typical gastrosopic appearance in hypertrophic gastritis is shown in Figure 5. Note the verrucous appearance of the mucosa on the lesser curvature near the angle of the stomach. Such small elevations are characteristic of the mucosal hyperplasia seen in chronic hypertrophic gastritis and are not visible by x-ray. Increased reddening and edema are also important evidence of inflammation as seen gastrosopically. Along the greater curvature in the same case (Fig 6) the rugæ are somewhat prominent and tortuous, with alternate widening and narrowing,

sometimes giving a bulbous or beaded appearance. Some of the folds show increased reddening along their crests. In this case x-ray examination showed slight enlargement of the rugæ, interpreted by Dr Schatzki as evidence of inflammation in the mucosa. In another case (Fig 7), however, we see by gastroscopy the characteristic beaded verrucous appearance of the mucosa in hypertrophic gastritis, yet the rugæ are small or absent and the x-ray examination was negative. Before gastroscopy this patient was thought to have a gastric neurosis. Gastroscopy here, as in other cases in which the diagnosis was not clear, has established a positive diagnosis of hypertrophic gastritis.

In chronic gastritis with erosions the gastroscope is also indispensable. A patient may come in with hematemesis or melena or both, x-ray examination of the stomach, duodenum, and colon is entirely negative. What is the source of the bleeding? Gastroscopy will frequently reveal erosions in the mucosa as shown in Figures 8, 9, and 10. Such erosions frequently occur on the crests of the rugæ, are only exceptionally visible by x-ray, and are undoubtedly the cause of bleeding in many cases.

Atrophic gastritis (3) is a disease seen chiefly in deficiency states, particularly pernicious anemia. X-ray examination may show small rugæ, but the diagnosis depends on gastrosopic examination. The characteristic appearance of the gastric mucosa in severe untreated pernicious anemia is shown in the illustrations (Figs 11 and 12). Note the very pale mucosa, complete absence of rugæ, and network of blood vessels clearly visible shining through the thin mucosa. After liver therapy there is a tendency for the mucosa to improve (Fig 13). The color has partly returned, blood vessels are no longer visible, and a few rugæ are now present.

Gastroscopy is also useful in gastric ulcer. X-ray examination is, of course, usually very accurate, and may demonstrate ulcers which are not found by gastroscopy. On the other hand, there are cases

in which a small ulcer is visible by gastroscopy and x-ray examination is negative. The gastroscopic appearance of benign

follows. "The stomach contained some secretion at the beginning of the examination, and there was marked prominence of

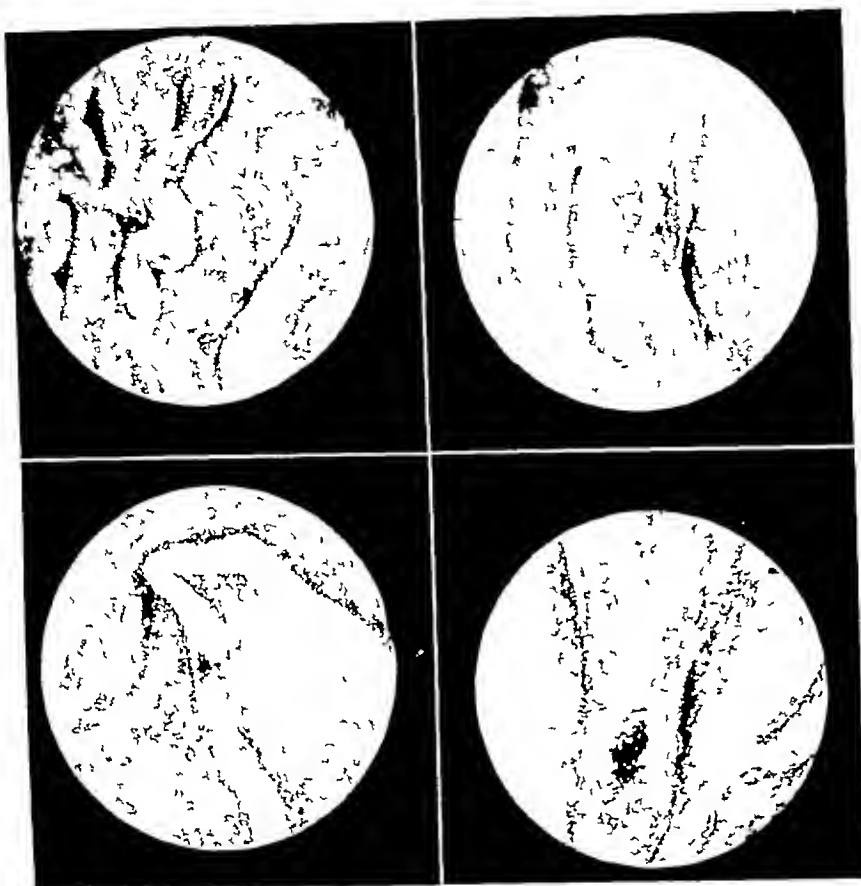


Fig 6 (*upper left*) Hypertrophic gastritis. Same patient as shown in Figure 5. Note alternate widening and narrowing of rugae.
 Fig 7 (*upper right*) Hypertrophic gastritis. Verrucous beaded appearance.
 Fig 8 (*lower left*) Small erosion on crest of tortuous fold.
 Fig 9 (*lower right*) Large superficial erosion on crest of wide fold in patient with otherwise unexplained hemorrhage.

ulcer is shown in the illustration (Fig 14). Note the smooth, red, clean-cut margins, and clean base, indicating its benign character. In Figure 15 a small benign ulcer is seen in its healing stage. These ulcers were also seen by x-ray. In Figure 16, however, gastroscopy demonstrated a small ulcer high up on the posterior wall near the cardia. This ulcer was not seen by x-ray examination.

In the differential diagnosis of gastric ulcer and carcinoma direct observation of the lesion by gastroscopy has been helpful. In a recent patient the x-ray report was as

its rugae throughout. Peristalsis began high on the greater curvature and passed without interruption to the pylorus. On the lesser curvature, however, there was no peristalsis distal to the angle of the stomach. Lying on the lesser curvature, just below the angle of the stomach, there was a 3-cm.-broad, shallow ulceration, with some thickening in the surrounding gastric wall. The walls of the stomach in this region were pliant throughout, and although peristalsis failed to pass over it, there was no evidence of rigidity. The patient complained of tenderness directly

over the lesion, but a definite mass could not be palpated. The findings are those of a definite lesion on the lesser curvature of

materially in the differential diagnosis showing on the lesser curvature at the angle of the stomach "a grayish shallow

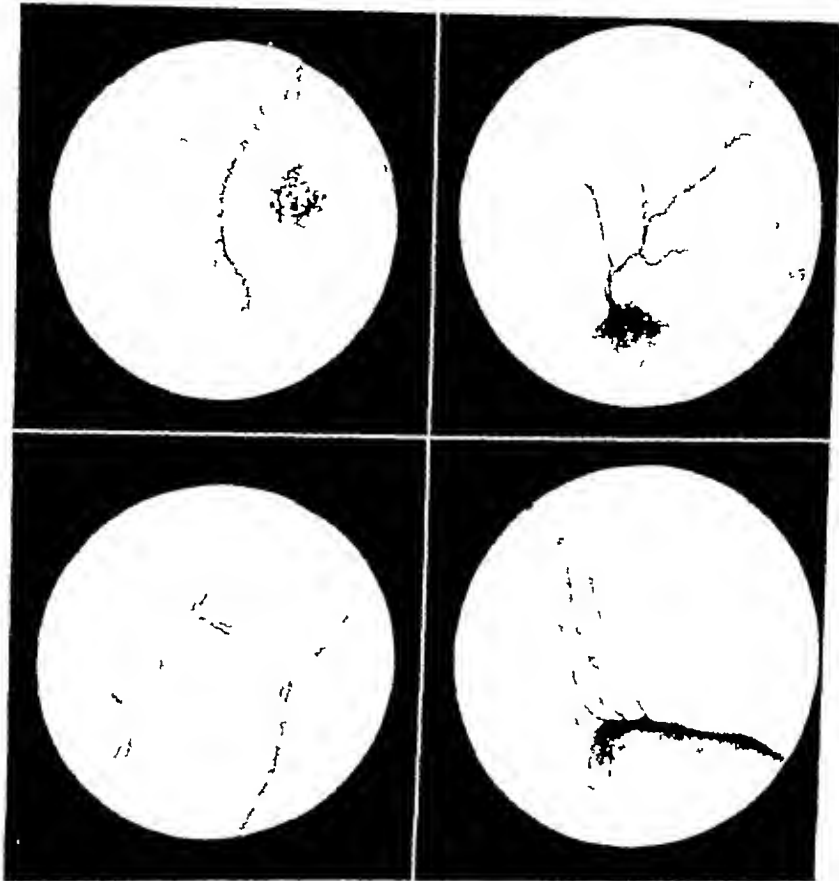


Fig 10 (upper left) Large superficial erosion on bulbous fold. Such erosions may be the cause of severe bleeding.

Fig 11 (upper right) Atrophic mucosa seen in untreated pernicious anemia. Note pallor, absence of rugæ, and network of blood vessels shining through the thin mucosa.

Fig 12 (lower left) Atrophic mucosa in another patient with untreated pernicious anemia. See Figure 11.

Fig 13 (lower right) Gastrosopic appearance of mucosa in pernicious anemia after liver therapy. Same patient as shown in Figure 12. Note improvement in color and rugæ.

the stomach just below the angle, the appearance of which is rather unusual. Taking the history into consideration, it seems possible that the patient may have an acute infection in the stomach wall at this point, with a shallow ulceration. The findings could also be due to an early benign peptic ulcer. Malignancy seems least likely but cannot be definitely excluded." Gastros-copy done two days later helped very

lesion about 0.5 cm in diameter, which appeared to be a benign healing ulceration." Four months later this patient was entirely symptom-free on medical treatment.

In five patients during the last two or three years the question of lymphoblastoma of the stomach has been raised by x-ray examination, and although the roentgenologist himself often considered it an

unlikely diagnosis, gastroscopy has given reassurance that lymphoma was not present. In these cases gastroscopy has either

tion regarding the extent and probable operability of the growth. For example, take the following x-ray report: "The

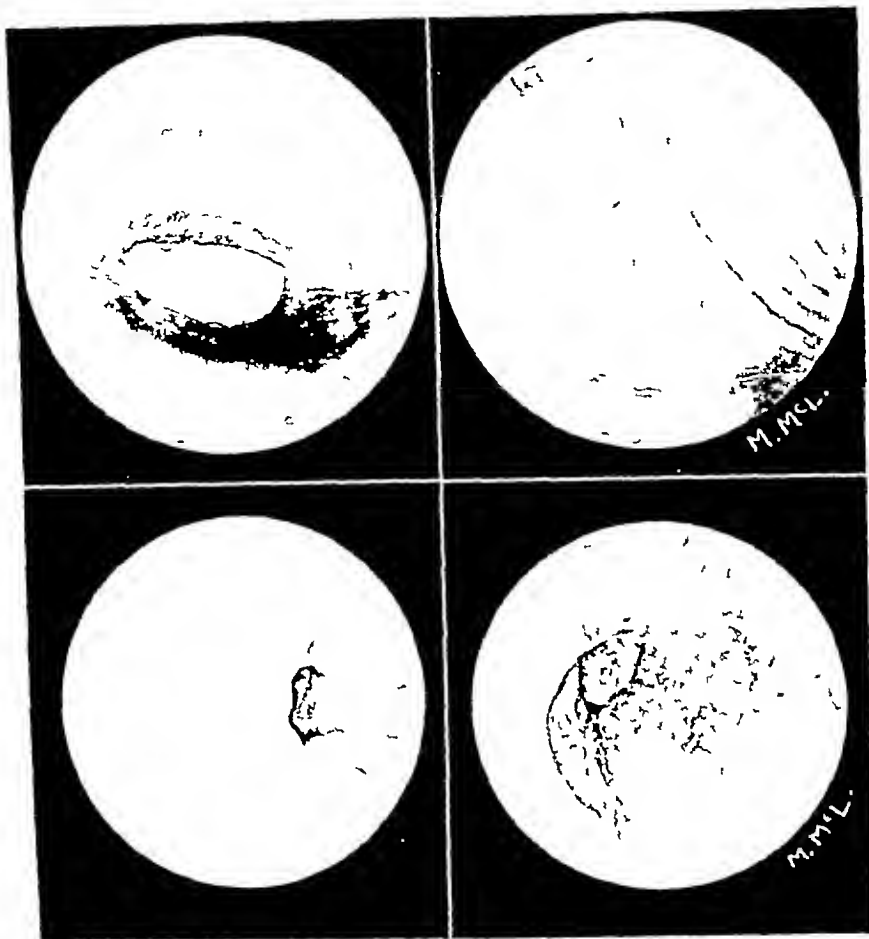


Fig 14 (upper left) Benign gastric ulcer as seen by gastroscopy. Its benign character is indicated by smooth clean-cut margins and clean base.

Fig 15 (upper right) Benign ulcer—healing.

Fig 16 (lower left) Small benign ulcer high up on posterior wall near the cardia. This ulcer was the cause of severe bleeding and was seen by gastroscopy but not by x-ray.

Fig 17 (lower right) Typical nodular gastroscopic appearance of proliferating carcinoma.

been negative or has shown hypertrophic gastritis. The subsequent course of these patients has been against lymphoblastoma.

Gastroscopy is also useful in carcinoma of the stomach (4), in spite of the fact that here roentgenology is highly accurate. The typical nodular gastroscopic appearance of proliferating carcinoma is shown in Figure 17. In malignant disease gastroscopy may aid in confirming the x-ray diagnosis and may add valuable informa-

tion. The stomach is unusually high in position, very small, and empties rapidly. As barium enters the stomach it is retained in the upper one-third until there is a moderate degree of distention of the fundus. Barium then passes over what appears to be an annular constriction which involves about one-half of the stomach. This constriction has the general appearance of a scirrhus carcinoma. Palpation and the usual type of examination was not possible, due to



Fig 18 (upper) Polypoid lesion of stomach as seen by gastroscopy Same patient as shown in Figure 11 This polyp, when very small, was first seen by gastroscopy 22 months ago but not confirmed by x ray Now very definite by gastroscopy and confirmed by x ray Resection Nov 27, 1936 Pathologic report adenocarcinoma Grade I (Note also improvement in color of mucosa and rugæ after liver therapy)

Fig 19 (lower) Photograph of resected tumor shown in Figure 18

inaccessibility of the stomach Syphilis could produce the picture " Gastroscopy in this case was of definite assistance in diagnosis No normal mucosa was seen The entire mucous membrane appeared studded with nodular protuberances which seemed to extend almost to the cardia It was felt by gastroscopy that the lesion was

malignant, with infiltration of most of the upper part of the stomach Exploratory laparotomy a few days later showed four-fifths of the stomach involved in new growth, which was inoperable, both because of its local size and fixation, and because of metastases Biopsy from a mesenteric gland showed metastatic adenocarcinoma

In the early diagnosis of neoplasm gastroscopy may be of great importance, as shown by the following case In January, 1935, a patient with pernicious anemia was examined by gastroscopy, marked atrophy of the mucosa was noted, with blood vessels shining through, as shown in Figure 11 In this patient, however, "on the greater curvature, near the antrum, there was a definite nodular protuberance about 2 cm long and 1 cm wide and raised above the mucosa about 0.5 cm The surface of this appeared smooth, but there seemed to be two or three distinct nodules merging together" X-ray examination six weeks later was reported as follows "Stomach is normal in position and outline Its rugæ showed some prominence, but no definite polypi could be demonstrated Duodenal cap and loop appeared normal Findings are those of moderate prominence of the gastric rugæ No other evidence of organic disease noted" One week later gastroscopy was repeated and again showed the protuberance previously noted The mucosa in general, however, showed an improvement in color and rugæ formation as a result of liver therapy, and it was decided to observe this patient longer on liver treatment in order to determine whether the condition was true polyp or perhaps a pseudo-polyposis, in which case there might be improvement on liver therapy Nine months later gastroscopy again showed a small polypoid lesion, which appeared smooth and non-malignant Eleven months then elapsed before the fourth gastroscopy, which showed a very marked increase in the size of the polyp, as shown in Figure 18 From previous experience with polypoid lesions of the stomach (5) it was felt that this tumor was probably malignant X-ray examination

now confirmed the gastroscopic findings, and a review of the films taken 22 months previously showed that the lesion should probably have been demonstrated by x-ray at that time. At operation the lesion was resected. The appearance of the pathologic specimen is shown in Figure 19. The pathologic report was adenocarcinoma, Grade I.

CONCLUSIONS

Gastroscopy is a valuable diagnostic aid in diseases of the stomach. It should not be used as a substitute for x-ray examination, but should be employed as an adjunct to it.

While gastroscopy is of great assistance in the diagnosis of small shallow ulcerations, in the differentiation of benign from malignant lesions of the stomach, in the early diagnosis of carcinoma, and in the observation of neoplasm with regard to its extent and operability, its chief field of usefulness lies in the study of the finer changes in the gastric mucosa, as in superficial, hypertrophic, and atrophic gastritis.

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THE COMPARATIVE VALUE OF GASTROSCOPY AND ROENTGEN EXAMINATION OF THE STOMACH¹

By RICHARD SCHATZKI, M D, Department of Roentgenology, Massachusetts General Hospital, Boston

In the first half of this paper the roentgen appearance of the inner surface of the stomach as it is seen in the normal and in some pathologic conditions will be briefly reviewed, before discussing in the second half the comparative advantages of gastroscopy and roentgenology (2). The conclusions which will be drawn are based on seven years of close co-operation with gastroscopists (Dr N Henning, of Leipzig, and Dr E B Benedict, of Boston).

Only a few words may be said about the well known picture of the normal gastric folds. They are soft and fairly straight on the anterior wall, more rigid and tortuous toward the greater curvature as well as in the fundus and on the posterior wall. The rugæ are formed by both mucosa and submucosa, a fact which should be kept in mind when interpreting pathologic conditions.

How does this picture change in gastritis? Does it change at all? These questions cannot be answered categorically. There are cases in which the roentgen film shows marked changes. The rugæ differ from those of the normal stomach, they are wider and higher. They are also more rigid, and one cannot make them disappear by pressure. All these changes indicate an increase in the thickness of those structures which form the rugæ, *i e*, the mucosa and the submucosa.

The thickness of the folds prompted the name of "hypertrophic gastritis" for these cases. It does not correspond exactly to what the gastroscopist means when he speaks of hypertrophic changes. He thinks of the hypertrophic new formations of the

mucosa itself, like warts or polyps, changes which—on account of their size—are rarely demonstrable by roentgen examination.

There are roentgen signs aside from the appearance of the rugæ which characterize gastritis, such as increased gastric secretion and small round areas of diminished density which are due to particles of mucus (Berg). One should hesitate to make the diagnosis of hypertrophic gastritis in the absence of this type of secretion, in other words, to make the diagnosis of gastritis in a dry stomach.

What does the gastroscopist see in cases like those just mentioned? If the changes are typical by x-ray he almost invariably finds gastritis, usually with marked hypertrophic warty changes of the mucosa. In rare instances, however, no gastritic changes are found by gastroscopy, and even atrophy may be present in exceptional cases.

Extensive degrees of hypertrophic gastritis may simulate cancer, as was emphasized by Cole. This is particularly true of cases with localized hypertrophic changes. By rotating the patient, it is usually possible to demonstrate the rugal character of the swelling and sometimes the transition of the swollen into the normal part of the rugæ. The possibility of the so-called "congenital giant rugæ," as described by Scherer and by Windholz, has to be considered in such cases.

A discrepancy between roentgen findings and gastroscopy is as a whole rather rare when changes typical of hypertrophic gastritis are demonstrated by roentgen examination. The converse is much more common. A large number of patients with an appearance of hypertrophic gastritis by gastroscopy show a normal roentgen picture. The changes in these cases ap-

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² The literature will not be quoted in detail. See papers in bibliography for extensive references.

parently involve the mucosa more than the submucosa. In other words, a negative roentgen examination does not exclude gastritis, whereas positive roentgen findings are usually more conclusive if interpreted with care and self-criticism.

Much more unsatisfactory is the roentgen diagnosis of *gastric atrophy*. Not infrequently, one may see the expected thinning of the rugæ, *e g*, in cases of pernicious anemia. The relief picture, however, may appear completely normal, though gastroscopy shows marked atrophy. On the other hand, I have seen stomachs with extremely thin rugæ in cachectic persons, *e g*, in a series of patients with advanced pulmonary tuberculosis, without there being the least evidence of atrophy by gastroscopic examination or functional tests (6). The thin rugæ in these cases are, therefore, not due to local disease of the mucosa but probably caused by dehydration of the entire body with consequent shrinking of the submucosa.

Taking everything into consideration, it is not possible to diagnose atrophy of the gastric mucosa conclusively by roentgen examination.

It was also thought that the third form of gastritis, the *ulcerative gastritis*, could not be demonstrated by the x-ray. This type is characterized by very shallow superficial erosions. A few years ago I succeeded for the first time, after several futile attempts, to obtain roentgen films of this condition, after it had been discovered during gastroscopy (5). Films were taken during fluoroscopy with measured pressure which showed numerous shallow ulcerations at the crests of the rugæ. Each of these ulcerations was surrounded by an edematous wall. Two months later, after medical treatment, the erosions had disappeared. They could not be found either by x-ray examination or by gastroscopy. This case, however, represents an exception. The shallowness of the erosions and the marked degree of accompanying gastric secretion usually prevent their demonstration.

Only a few words may be said in regard

to the possibilities of the roentgen demonstration of gastric tumors. Small tumors can be recognized as such even though their size may barely surpass the width of a gastric fold.

The exact delineation of the tumor is of great importance to the surgeon. The changes of the relief picture of the stomach coincide closely with the intragastric extent of the tumor. Multiple tumors can be separated and recognized as such.

This résumé of the roentgenologic possibilities seemed necessary before giving a comparison of the advantages and disadvantages of gastroscopy and x-ray examination of the stomach. This will naturally represent my own experience which, as mentioned before, is based on seven years of close co-operation with gastroscopists.

First, something may be said about the advantages of gastroscopy. It is certainly superior to x-ray from the purely optical standpoint. It is done with precise instruments, such as lenses and mirrors, giving the same optical impression as the naked eye would have. It is even superior to this, as it gives a slightly magnified picture. Roentgenograms are comparatively crude pictures, considering the grain of the contrast meal, of the film, and the screen, and other obvious limitations.

The conclusion must be that gastroscopy is superior to x-ray examination in the diagnosis of minute changes of the inner surface.

Another advantage of gastroscopy is the ability to see colors. Roentgen diagnosis is based only on differences in the level of the crests and valleys of the inner surface, whereas gastroscopy has this additional help of difference in color.

Roentgenology, on the other hand, possesses other advantages. There are at first some practical ones. It is easier and still less dangerous to do an x-ray examination than to do a gastroscopy. X-ray is, therefore, more fit for routine clinical work.

Moreover, it is possible to demonstrate all portions of the stomach by x-ray examination, whereas it is difficult, sometimes even impossible, to see certain parts of the

stomach by gastroscopy, *e g*, parts of the fundus or of the lesser curvature of the antrum. Roentgenology is, therefore, superior to gastroscopy in cases in which it is necessary to search every corner of the stomach in order to demonstrate a circumscribed, not diffuse, lesion.

Roentgenology is further superior to gastroscopy in regard to the description of the extent of a lesion, as the endoscope rather often can demonstrate only its upper margin, although it may sometimes do this more accurately than the x-ray examination.

There is, finally, a more important advantage of x-ray, *ie*, the routine observation of peristalsis of the whole stomach as well as the impression obtained by manual palpation which gives information concerning flexibility or rigidity of the wall. In other words, roentgenology is superior in the demonstration of the processes in the deeper layers of the stomach wall.

If one applies the principal differences of the two methods to their diagnostic possibilities in the various lesions of the stomach, one comes to the following conclusions:

(1) *Concerning gastritis*. There are cases in which it is possible to make a definite diagnosis of gastritis by x-ray. There are, however, a large number of cases of gastritis which are completely negative by x-ray. Gastroscopy is, therefore, by far the best method of examination for the diagnosis of gastritis.

(2) *Concerning ulcer*. It is usually easier to discover large ulcers by x-ray and to describe their size and position.

A control gastroscopic examination of the surrounding surface and of the crater base for the question of malignant degeneration may be of great importance, however.

Ulcers, which on gross examination by the pathologist appear benign but prove to be malignant by microscopic examination, cannot be diagnosed as such by any method of macroscopic examination.

Small ulcers of the stomach may be easily overlooked by x-ray examination. It may be even impossible to see a small

ulcer by the x-ray though the exact localization is known by a preceding gastroscopy. On the other hand, ulcers, definite by x-ray, may be overlooked by gastroscopy, or it may be impossible to bring them into the field of the scope.

I have seen examples of both possibilities, and I think that the efficiency of both methods is about the same in this regard.

Healing of gastric ulcers, indicated by a decrease in size and shape of the niche and later the formation of the "rugal star," can be well followed by roentgen examination. There is, however, no doubt that gastroscopy is superior in regard to the observation of the final healing process of the mucosa.

(3) *Concerning tumors of the stomach*

The diagnosis of tumors of the stomach, including cancers, is usually much easier and more certain by x-ray.

A gastroscopic control, however, may be of utmost importance if there is any question about the nature of a small tumor-like defect (such as, when there is a question of tumor or unusual mucosal fold), or if we are dealing with the differential diagnosis between hypertrophic gastritis and diffuse cancerous or lymphoblastomatous infiltration, a decision which may be extremely difficult by x-ray examination. The similarity between these lesions may be so great that even the direct visualization of the lesion through the gastroscope may not lead to a definite diagnosis. I have seen the diagnosis of malignancy made by gastroscopy in a few cases of gastritis.

The help which gastroscopy offers in the differential diagnosis of intrinsic and extrinsic lesions of the stomach in difficult exceptional cases cannot be over-estimated.

Finally, it is worth-while to mention the fact that gastroscopic control may correct obvious mistakes in x-ray examination and interpretation.

Summarizing, if one should be asked to renounce either gastroscopy or roentgenology, one would without doubt prefer to keep roentgenology, but the question is wrong in itself. Gastroscopy is an important supplementary method. A diagnostic

problem may be difficult to solve by roentgenology and may be no problem at all for gastroscopy and *vice versa*. The correlation of the findings by the two methods has increased our knowledge of the normal and diseased stomach and has helped us in many individual cases.

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RELATIVE MERITS OF GASTROSCOPIC AND ROENTGENOLOGIC EXAMINATION

By B R KIRKLIN, M D , *Rochester, Minn*

Section on Roentgenology, The Mayo Clinic

AT the outset I wish to insist strongly that if there is any rivalry between roentgenologic and gastroscopic methods of examination, it is altogether friendly. If the gastroscope will disclose and identify lesions that escape roentgenologic revelation and recognition, then by all means let it come into more common use. Any method that makes for a closer approach to accuracy in diagnosis deserves a hearty welcome. In this instance, however, the margin for potential improvement is narrow, for in competent hands, such as are available almost everywhere, the roentgen ray will disclose at least 95 per cent of lesions that could be seen by direct inspection, and will permit a specific diagnosis of most of them.

The gross lesions, including the advanced cancers and benign newgrowths, have such striking roentgenologic characteristics, demonstrable even by the simplest techniques, that few errors in diagnosis are permissible. It is true that the primarily benign tumors often contain malignant cells, but as a rule, a painstaking microscopic search is necessary to reveal these cells, and it is scarcely conceivable that they could be discovered by gastroscopic inspection.

But the efficiency of roentgenologic examination is not confined to gross lesions. By coating the mucosal surface of the stomach with a thin layer of barium at the beginning of the examination, as is commonly done, exceedingly small lesions can be exhibited roentgenoscopically and usually thus identified. To the adjunctive roentgenographic feature of this procedure the term "compression technic" is now applied and those who are uninformed are inclined to suppose that the method is fundamentally new. As a matter of fact employment of a thin coating for roent-

genoscopy was introduced by Holzknecht in the early days of roentgenologic gastro-intestinal diagnosis, and has long been part of the standard routine. Further, roentgenoscopic inspection is practically indispensable to disclose and localize lesions prior to applying compression roentgenography, which also is in common use, chiefly for the preservation of a record.

By coating the mucosa with a thin layer of the opaque medium any gastric lesion, whether ulcerative or tumefactive, that visibly alters the internal topography of the stomach is demonstrable even when the diameter of the lesion is only a few millimeters, and any failure to find it should be charged against the examiner, not against the method. Minute ulcerating carcinomas can confidently be diagnosed as such, for the meniscus sign complex produced by the slight elevation of the crater margin is pathognomonic. Yet often in such instances the surgeon, after he has opened the stomach and exposed the lesion to view, is unable to say whether it is benign or malignant, nor after its removal can the pathologist determine its character by macroscopic inspection. It has been claimed that the gastroscopist can make this distinction in every case, but if this is true I cannot understand why an experienced surgeon looking closely and directly at these small ulcerating carcinomas is often unable to distinguish them from benign ulcers.

Similarly, malignant ulcer without any marginal tumefaction sometimes betrays its character roentgenoscopically by the irregular profile of its crater, but the irregularity would scarcely be detectable in the gastroscopic face view. As for the malignant ulcers that have the macroscopic appearance of benign ulcers and cannot be identified by the roentgenologist, or macroscopically by the surgeon or

pathologist, I fail to see how they could be recognized by the gastroscopist. In short, roentgenologic examination is almost as reliable as macroscopic inspection in determining whether a gastric lesion is malignant or benign. If the gastroscope can excel the roentgen ray or the unaided and unhampered eye in this regard, it will be useful indeed.

Not for a moment do I contend that the roentgenologic method is infallible or that it has no limitations. Some of the limitations I have already pointed out, but there are others. Often by this method it is impossible to determine the exact nature of prepyloric lesions whose presence is obvious. Both early cancer in this region and benign prepyloric ulcer with spasm convert the distal antrum into a narrow distorted canal, and frequently neither condition has any definite distinguishing marks. At one time hypertrophy of the pyloric muscle, which produces similar findings, often was indistinguishable from prepyloric cancer or ulcer, but the differential characteristics of pyloric hypertrophy have been learned and a roentgenologic diagnosis can be made in most cases.

Drs Schundler and Templeton have mentioned some of the limitations of gastroscopy, *e g*, that in many instances there are blind spots in the stomach that cannot be inspected with the gastroscope, notably the dome of the cardia, the lesser curvature distal to the angle, and a portion of the greater curvature opposite the angle. Inspection of the duodenal bulb is an essential feature of the gastric examination and cannot be effected with the gastroscope. None of these limitations apply to the roentgen ray for it will exhibit anatomic changes in any part of the gastric or duodenal lumen.

One concession to gastroscopy I offer willingly and that is its generally recognized ability to establish or exclude the presence of chronic gastritis. Here the roentgen ray is not altogether inadequate, and some of the European roentgenologists have become proficient in making the diagnosis. Chronic gastritis of the ulcerative

type is recognizable roentgenologically by its characteristic multiple small erosions, which in the face view are marked by fleck-like deposits of barium and appear in the tangential view as sharply pointed indentations in the mucosa. Lately, also, by following the dicta of my good friend, Hans Heinrich Berg, I have ventured the diagnosis of localized hypertrophic gastritis in several cases and was fortunate enough to have the diagnosis confirmed by gastroscopy in every instance. Nevertheless, I feel that the roentgenologic method has many limitations in the diagnosis of non-ulcerative chronic gastritis, that there is still much to learn in regard to technic and interpretation, and that gastroscopy should be carried out in every suspected case in order to confirm or correct the roentgenologic opinion. Further, I hope that neither the roentgenologic nor the gastroscopic diagnosis of gastritis will become common until the morbid anatomy of the disease, its right to be considered a pathologic entity, and its clinical significance become better understood and more firmly established.

It has been publicly urged that gastroscopy be applied as a routine in examination of the stomach. It seems to me that this will not be warranted until it has been shown conclusively that gastroscopy is more uniformly accurate in diagnosis than roentgenoscopy and is attended with as little risk to the patient. As is well known, in several instances the stomach has been perforated by the gastroscope and with fatal results. When medical roentgenology was new it suffered from the enthusiastic claims of its ardent practitioners and its progress was retarded. It is to be hoped that this history will not be repeated in the case of the gastroscope.

Notwithstanding all these doubts, reservations, and cautions, I am convinced that gastroscopy has already won a place as a useful adjunct in the diagnosis of gastric diseases, and if its applications can be extended with facility, safety, and substantial benefit, I shall gladly join in the general applause.

RELATIVE MERITS OF GASTROSCOPIC AND ROENTGENOLOGIC EXAMINATION

By B R KIRKLIN, M D, *Rochester, Minn*

Section on Roentgenology, The Mayo Clinic

AT the outset I wish to insist strongly that if there is any rivalry between roentgenologic and gastroscopic methods of examination, it is altogether friendly. If the gastroscope will disclose and identify lesions that escape roentgenologic revelation and recognition, then by all means let it come into more common use. Any method that makes for a closer approach to accuracy in diagnosis deserves a hearty welcome. In this instance, however, the margin for potential improvement is narrow, for in competent hands, such as are available almost everywhere, the roentgen ray will disclose at least 95 per cent of lesions that could be seen by direct inspection, and will permit a specific diagnosis of most of them.

The gross lesions, including the advanced cancers and benign newgrowths, have such striking roentgenologic characteristics, demonstrable even by the simplest techniques, that few errors in diagnosis are permissible. It is true that the primarily benign tumors often contain malignant cells, but as a rule, a painstaking microscopic search is necessary to reveal these cells, and it is scarcely conceivable that they could be discovered by gastroscopic inspection.

But the efficiency of roentgenologic examination is not confined to gross lesions. By coating the mucosal surface of the stomach with a thin layer of barium at the beginning of the examination, as is commonly done, exceedingly small lesions can be exhibited roentgenoscopically and usually thus identified. To the adjunctive roentgenographic feature of this procedure the term "compression technic" is now applied and those who are uninformed are inclined to suppose that the method is fundamentally new. As a matter of fact employment of a thin coating for roent-

genoscopy was introduced by Holzknecht in the early days of roentgenologic gastro-intestinal diagnosis, and has long been part of the standard routine. Further, roentgenoscopic inspection is practically indispensable to disclose and localize lesions prior to applying compression roentgenography, which also is in common use, chiefly for the preservation of a record.

By coating the mucosa with a thin layer of the opaque medium any gastric lesion, whether ulcerative or tumefactive, that visibly alters the internal topography of the stomach is demonstrable even when the diameter of the lesion is only a few millimeters, and any failure to find it should be charged against the examiner, not against the method. Minute ulcerating carcinomas can confidently be diagnosed as such, for the meniscus sign complex produced by the slight elevation of the crater margin is pathognomonic. Yet often in such instances the surgeon, after he has opened the stomach and exposed the lesion to view, is unable to say whether it is benign or malignant, nor after its removal can the pathologist determine its character by macroscopic inspection. It has been claimed that the gastroscopist can make this distinction in every case, but if this is true I cannot understand why an experienced surgeon looking closely and directly at these small ulcerating carcinomas is often unable to distinguish them from benign ulcers.

Similarly, malignant ulcer without any marginal tumefaction sometimes betrays its character roentgenoscopically by the irregular profile of its crater, but the irregularity would scarcely be detectable in the gastroscopic face view. As for the malignant ulcers that have the macroscopic appearance of benign ulcers and cannot be identified by the roentgenologist, or macroscopically by the surgeon or

feet nor any great amount of dyspnea, although he stated that at times he had had fainting sensations, which had been ascribed to his gastro-intestinal condition

The patient was in James Walker Hospital, Wilmington, N C, for a period of treatment for the gastro-intestinal condition mentioned above. While there, he was put on a rather scant diet consisting of milk and cereals. He was discharged from that hospital on Sept 7, 1935, and on the following day, being still on a very scant diet, his stomach was empty and he felt very hungry. In short, while he was out in the field where some persimmon trees grew, he ate persimmon fruit—he estimated the amount to be perhaps one and one-half pints. This was about four o'clock in the afternoon. He returned to the house and ate nothing further before retiring except some soup. Some time during the night, he became nauseated and vomited. He did not recall that there were any of the remains of the persimmons in the vomitus. He thought that he had considerable fever but his temperature was not taken. From then to the time of hospitalization he continued to have attacks of pain in the epigastrium, some nausea at times, but never vomited again.

The patient was of rather senile appearance, emaciated, and poorly nourished. His given age was 59 years, his apparent age was 70. His blood pressure 154/92, pulse, 104. Examination of the abdomen gave the impression that the liver was somewhat enlarged, however, there was also a mass in the epigastrium about the size of a medium-sized orange. This was slightly to the left of the median line and somewhat movable. Gastric analysis was made and the total acidity reported as 56, free HCl, 48, blood, negative.

Operation was performed by Dr H D Coffee on Dec 9, 1935. The stomach was greatly dilated, and there were found therein masses, firm in consistency, and about the size of a golf ball. There was an area of redness and congestion of the mucous membrane of the stomach at the pylorus. A right rectus incision was made and the stomach was exteriorized. Incision was made in the middle of the anterior surface of the stomach parallel with its long axis, and the foreign bodies were removed from it.

The post-operative condition of the patient was poor. Convalescence was rather stormy because of the extreme emaciation and dehydration. He was given saline and glucose intravenously for three days, after which a liquid diet was allowed. He gained 30 pounds in weight after the operation and was discharged from the hospital as having received maximum hospital benefit.

Upon pathological examination, the specimen removed from the stomach consisted of two black masses, irregular in shape. The surface was irregular and the ends of the masses appeared to have been broken. The total

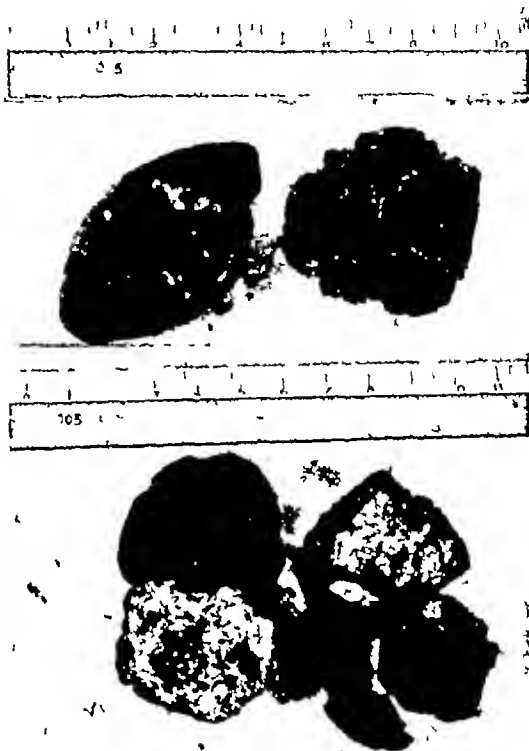


Fig 3 (above) Showing the conical mass that was difficult to dislodge from the pylorus. The square mass fitted rather loosely against the conical mass.

Fig 4 (below) Phytobezoar broken up, showing pulp, skins and seed.

weight was 64 grams. Upon sectioning, the central portion was seen to be of a light yellow (Figs 3 and 4), numerous seeds were present, the size of persimmon seeds. There was a mild fermentative odor present. Anatomical diagnosis was *Phytobezoar diospyri virginianæ*.

SUMMARY AND CONCLUSIONS

Thirty-two cases of *Phytobezoar diospyri virginianæ* have been previously collected from the American literature and one new case is reported.

The ideal conditions for the formation of phytobezoar existed in this case, *i e*, hunger, an empty stomach, hydrochloric acid, and persimmons.

CASE REPORTS AND NEW DEVICES

PHYTOBEZOAR OF PERSIMMON ORIGIN

B, FLOYD D RODGERS M D, Columbia,
South Carolina

In 1935, Dr Harry C Schmeisser, of Memphis, Tenn, reported¹ two cases of phytobezoar of persimmon origin, and in his search of the literature he had found 30 authentic cases of this type, his own two cases making 32 The one reported below makes 33

Case 1 F H, white, male, a farmer, aged 59 years, was admitted to the Veterans' Hospital for treatment of hemorrhoids He was sent to the x-ray department for a routine gastro-intestinal examination on Nov 9, 1935, with a history of gastro-intestinal distress The fluoroscopic examination clearly demonstrated that there was a foreign body in the stomach In fact, on manipulation, the observer realized that he was dealing with two foreign bodies In the first examination, it was rather difficult to dislodge the cone shaped body in the pyloric end of the stomach, but the larger half of the mass could be freely moved

in the cardiac end The patient was asked to return on the following morning for further investigation On his arrival, the next day, he remarked that the manipulation had cured him, as he had had a comfortable night and felt fine.



Fig 2 Foreign bodies may be seen, with a small amount of barium in the stomach

After the discovery of these foreign bodies, the observer immediately thought of the phytobezoar of persimmon origin and questioned the patient along this line His story was a classic

History—The patient had had chronic constipation extending back over a period of at least 20 years, but had been considerably worse during the past year He had taken cathartics, and for the past seven months it had been necessary to take a cathartic of some kind or there would be no bowel movement at all He had a considerable accumulation of gas in the gastro-intestinal tract at times Occasionally, he was slightly nauseated but there had been few attacks of vomiting He had no history of epigastric pain There had been no vomiting of blood, nor bleeding from the intestinal tract other than from the hemorrhoids for which he was admitted to the hospital His gastro-intestinal symptoms bore no relation to meals and were not seasonal in type He denied that he had ever been jaundiced The patient gave no history of any edema of the



Fig 1 Both masses are clearly demonstrated with a small amount of barium clinging to the phytobezoar as it does not penetrate the mass.

¹ South Med Jour November 1935, 28, 987-992

feet nor any great amount of dyspnea, although he stated that at times he had had fainting sensations, which had been ascribed to his gastrointestinal condition

The patient was in James Walker Hospital, Wilmington, N C, for a period of treatment for the gastro-intestinal condition mentioned above. While there, he was put on a rather scant diet consisting of milk and cereals. He was discharged from that hospital on Sept 7, 1935, and on the following day, being still on a very scant diet, his stomach was empty and he felt very hungry. In short, while he was out in the field where some persimmon trees grew, he ate persimmon fruit—he estimated the amount to be perhaps one and one-half pints. This was about four o'clock in the afternoon. He returned to the house and ate nothing further before retiring except some soup. Some time during the night, he became nauseated and vomited. He did not recall that there were any of the remains of the persimmons in the vomitus. He thought that he had considerable fever but his temperature was not taken. From then to the time of hospitalization he continued to have attacks of pain in the epigastrium, some nausea at times, but never vomited again.

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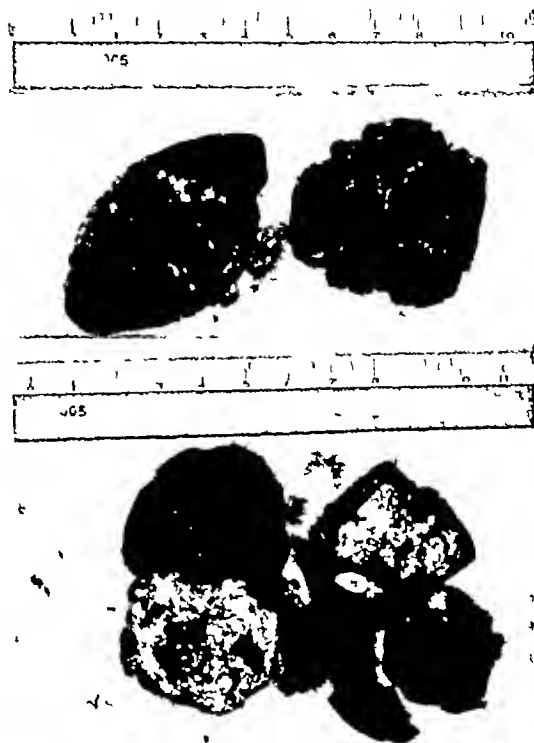


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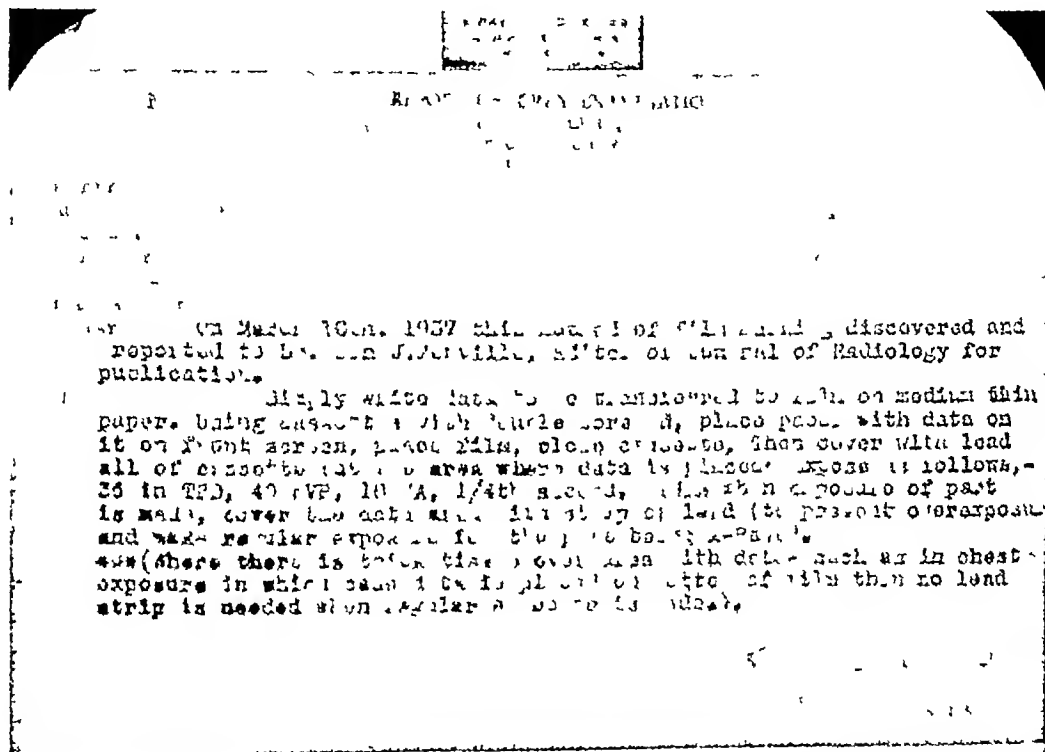
The ideal conditions for the formation of phytobezoar existed in this case, i.e., hunger, an empty stomach, hydrochloric acid, and persimmons.

A METHOD OF RECORDING ON FILM PERTINENT DATA RELATIVE TO PATIENT

By RICHARD C CURTIS M.D. *Corpus Christi, Texas*

To record on the film pertinent information regarding a patient, either type or write out on moderately thin paper the words and figures to be impressed on the film. Place the

paper on the intensifying screen in the cassette, then place the film over the paper and close the cassette. (I use one end of the cassette for record.) Cover the cassette with a sheet of lead, leaving exposed the area under which lies the written sheet of paper, and expose as follows: 35 kv p, 10 ma, 36 in., for one fourth second. This makes the impression. When the exposure of the patient is made, simply



place a narrow strip of lead over the area that has been exposed for record in order to prevent over-exposure of the data strip. However, if some thick portion of tissue is over the record, the latter will not be over-exposed, even if no strip of lead is used.

In brief, this method consists of just a decrease in the intensification of the intensifying screen at the point of contact of written or printed matter. The patient's signature also may be recorded in this fashion.

This may prove a starting point for a better method of marking films, especially films which may possibly be introduced as evidence in medico-legal cases.

AN UNUSUAL CONGENITAL ANOMALY OF THE SPINE

By I MILTON WISE B.S., M.D., *Mobile, Alabama*

A brief discussion of the embryological development of bone is presented. This may help to explain the congenital anomaly of the spine in this case.

In the formation of the vertebrae in the embryo the mesenchyme from the sclerotomes grows mesad and comes to lie in paired masses on either side of the notochord, separated from similar masses before and behind by intersegmental arteries. In embryos of about four

masses now grow toward the median line and enclose the notochord, thus establishing the body of each vertebra. Similarly, dorsal extensions form the vertebral arch. The looser tissue of the cranial halves also grows mesad and fills the intervals between the more dense regions. The more dense caudal half of each sclerotomic mass presently unites with the less dense cranial half of the sclerotome next caudad to form the anlagen of the definitive vertebra.

Following the blastemal stage, centers of chondrification appear, two centers in the vertebral body and one in each half of the arch. These centers enlarge and fuse to form a cartilaginous vertebra. Transverse and articular processes grow out from the arch, the various ligaments arise from mesenchyme surrounding the vertebrae, and at the end of the eighth week the stage of ossification sets in. A single center appears in the body and one in each half of the arch (1).

Case Report—S. T., white female, 39 months of age, was sent for roentgenologic examination of the spine, with a provisional diagnosis of Pott's disease. The infant had been a breech presentation at full term. Notice was taken at birth that the infant seemed to have a longer body than normal. At four months, the child sat up, and at that time a curvature was noted in the lumbar area. This seemed to grow less so that it almost disappeared. At twelve months, the child walked without difficulty.

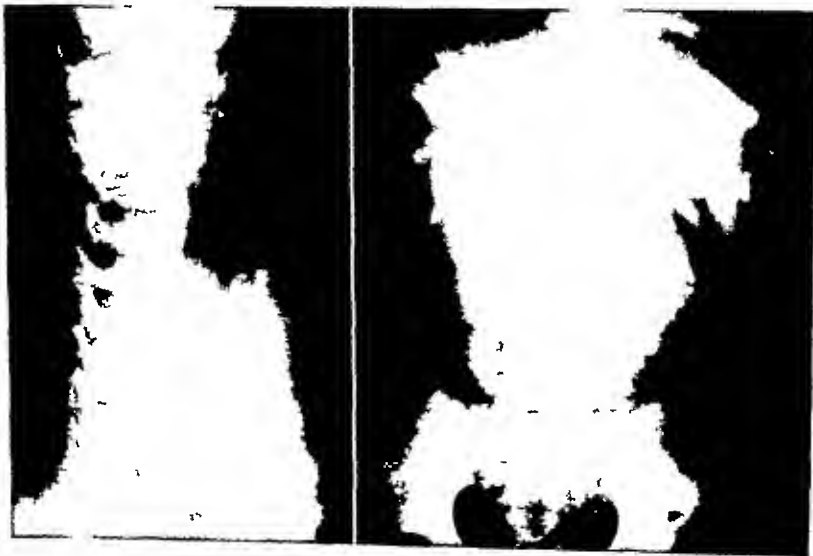


Fig 1

Fig 2

millimeters, each sclerotome soon differentiates into a caudal, compact portion and a less dense portion. From the former, horizontal trans-

She did not limp, and fell no more often than does the average child of similar age. The

nence in the child's lumbar area which she had noted during the last several months

Roentgenographic examination of the spine

REFERENCE

- (1) PRENTISS and ARRY Text book of Embryology, second ed W B Saunders Company, 1918, pp 309, 310



Fig 1 An exposure made with the use of the wedge is shown on the left, without the wedge on the right (See below)

in the anteroposterior position reveals six lumbar vertebra. The vertebral arches are not completely formed, and there exists almost a spina bifida of the fifth vertebra. The arch is closed only by a thin bony wall. Two lateral masses of bone are present on the left above and on the right below the body of the vertebra. Each mass has its own transverse process. The body of the vertebra is slightly tilted and the arch is apparently formed by the union of the center of ossification for the arch of the third vertebra on the right and the center of ossification for the arch of the fourth vertebra on the left. The centers of ossification for the arch of the third vertebra on the left and for the fourth on the right, with their transverse processes, form the unattached masses of bone. In the lateral view the bodies of the third and fourth vertebrae are fused, with a fusion, also, of the spinous processes.

SUMMARY

An unusual case of congenital anomaly of the vertebral column due to atypical fusion of the centers of ossification for the vertebral arch and the presence of six lumbar vertebrae is herewith presented.

DR CARPENTER'S ALUMINIUM WEDGE

By I S TROSTLER M.D., F.A.C.R., F.A.C.P.,
Chicago

For the last five or six years I have been using a simple gadget made for me by Dr. John H. Carpenter of this city, which, because of its simplicity and adaptability should be in general use.

Ordinarily, roentgenograms of the foot in the dorso-plantar position are over-exposed in the toes and distal ends of the metatarsals if fully exposed for the tarsal bones. With the use of this gadget, the exposure of the entire foot is equal and all of the bones are equally clearly shown.

The device is simply a wedge of aluminum $3\frac{1}{2}$ by $3\frac{1}{2}$ inches in size. It is one-half inch thick on one side and tapers down to a feather edge at the other side. This is placed in the tube stand, near the tube, with the thick edge away from the body and toward the toes, and the exposure made as for the ankle.

It is evident that this wedge acts as a filter, equalizing the exposure, as may be seen from the accompanying illustrations.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALENDAR

MEETING FALLING BETWEEN THE DATES OF OCT 15 and NOV 30

November 20 Texas Radiological Society annual meeting at the Adolphus Hotel, Dallas, Texas

CALIFORNIA

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY *Chairman*, John D Lawson, M D, 1306 California State Bldg, Sacramento, *Secretary*, Karl M Bonoff, M D, 1930 Wilshire Blvd, Los Angeles Meets annually with California Medical Assn

LOS ANGELES COUNTY MEDICAL ASSOCIATION, RADIOLOGICAL SECTION *President*, D R McColl, M D, *Vice-president*, John F Chapman, M D, *Secretary*, E N Liljedahl, M D, *Treasurer*, Henry Snure, M D Meets every second Wednesday of month at County Society Building

PACIFIC ROENTGEN CLUB *Chairman*, Raymond G Taylor, M D, 1212 Shatto St, Los Angeles, *Secretary*, L Henry Garland, M D, 450 Sutter St, San Francisco

COLORADO

DENVER RADIOLOGICAL CLUB *President*, W Walter Wasson, M D, 246 Metropolitan Bldg, *Vice-president*, Ernst A Schmidt, M D, Colorado General Hospital, *Secretary*, Nathan B Newcomer, M D, 306 Republic Bldg *Treasurer*, Leonard G Crosby, M D, 366 Metropolitan Bldg Meets third Tuesday of each month at homes of members

CONNECTICUT

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY *Chairman*, Kenneth K Kinney, M D, 29 North Street, Willimantic, *Vice-chairman*, Francis M Dunn, M D, 100 State Street, New London, *Secretary-Treasurer*, Max Climan, M D, 242 Trumbull St, Hartford Meetings twice annually in May and September

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society

FLORIDA

FLORIDA STATE RADIOLOGICAL SOCIETY *Presi-*

dent, Gerald Raap, M D, 168 S E First St, Miami, *Vice-president*, H O Brown, M D, 404 First Nat'l Bank Bldg, Tampa, *Secretary-Treasurer*, H B McEuen, M D, 126 W Adams St, Jacksonville

ILLINOIS

CHICAGO ROENTGEN SOCIETY *President*, David S Beilin, M D, 411 Garfield Ave, *Vice-president*, Chester J Challenger, M D, 3117 Logan Blvd, *Secretary-Treasurer*, Roe J Maier, M D, 7752 Halsted St Meets second Thursday of each month, September to May, except December

ILLINOIS RADIOLOGICAL SOCIETY *President*, Ivan Brouse, M D, 316 W State, Jacksonville, *Vice-president*, Cesar Gianturco, M D, Carle Hospital Clinic, Urbana, *Secretary-Treasurer*, Edmund P Halley, M D, 968 Citizens Bldg, Decatur Meetings quarterly by announcement

ILLINOIS STATE MEDICAL SOCIETY, SECTION OF RADIOLOGY *President*, Roswell T Pettit, M D, 728 Columbus St, Ottawa, *Secretary*, Ralph G Willy, M D, 1138 N Leavitt St, Chicago

INDIANA

INDIANA ROENTGEN SOCIETY *President*, J N Collins, M D, 23 E Ohio St, Indianapolis, *President-elect*, Stanley Clark, M D, 108 N Main St, South Bend, *Vice-president*, Juan Rodriguez, M D, 2903 Fairfield Ave, Fort Wayne, *Secretary-Treasurer*, Clifford C Taylor, M D, 23 E Ohio St, Indianapolis Annual meeting in May

IOWA

THE IOWA X-RAY CLUB Holds luncheon and business meeting during annual session of Iowa State Medical Society

MAINE

See New England Roentgen Ray Society

MARYLAND

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION *Secretary*, H E Wright, M D, 101 W Read St, Baltimore Meetings each Monday night

MASSACHUSETTS

See New England Roentgen Ray Society

MICHIGAN

DETROIT X-RAY AND RADIUM SOCIETY *Presi-*

dent, C C Birkelo, M D, Herman Keifer Hospital, *Vice-president*, E W Hall, M D, 10 Peterboro St, *Secretary-Treasurer*, E R Witwer, M D, Harper Hospital Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society Bldg

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS *President*, J C Kenning, M D, 1536 David Whitney Bldg, Detroit, *Vice-president*, A W Chase, M D, 133 Toledo St, Adrian, *Secretary-Treasurer*, C S Davenport, M D, 609 Carey St, Lansing

MINNESOTA

MINNESOTA RADIOLOGICAL SOCIETY *President*, Walter H Ude, M D, 78 S 9th St, Minneapolis, *Vice-president*, Leo G Rigler, M D, University Hospitals, Minneapolis, *Secretary-Treasurer*, Harry Weber, M D, 102 Second Ave, S W, Rochester Meetings quarterly

MISSOURI

THE KANSAS CITY RADIOLOGICAL SOCIETY *President*, L G Allen, M D, 907 N 7th St, Kansas City, Mo, *Secretary*, Ira H Lockwood, M D, 306 E 12th St, Kansas City, Mo Meetings last Thursday of each month

THE ST LOUIS SOCIETY OF RADIOLOGISTS *President*, Joseph C Peden, M D, 634 N Grand Blvd, *Secretary*, W K Mueller, M D, 607 N Grand Blvd Meetings fourth Wednesday of each month

NEBRASKA

NEBRASKA STATE RADIOLOGICAL SOCIETY *President*, Howard B Hunt, M D, 4740 Hickory St, Omaha, *Secretary*, D Arnold Dowell, M D, 117 S 17th St., Omaha Meetings first Wednesday of each month at 7 P M in Omaha or Lincoln

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut) *President*, Frank E Wheatley, M D, 520 Beacon St, Boston, *Secretary*, E C Vogt, M D, 300 Longwood Ave, Boston Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library

NEW HAMPSHIRE

See New England Roentgen Ray Society

NEW JERSEY

NEW JERSEY STATE RADIOLOGICAL SOCIETY

President, W W Maver, M D, 532 Bergen Ave, Jersey City, *Vice-president*, J D Tidaback, M D, 382 Springfield, Summit, *Secretary*, P S Avery, M D, Middlesex General Hospital, New Brunswick Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by President

NEW YORK

BROOKLYN ROENTGEN SOCIETY *President*, Albert Voltz, M D, 115-120 Myrtle Avenue, Richmond Hill, *Vice-president*, A L L Bell, M D, Long Island College Hospital, Henry, Pacific, and Amity Sts, Brooklyn, *Secretary-Treasurer*, E Mendelson, M D, 132 Parkside Ave, Brooklyn Meetings first Tuesday in each month at place designated by president.

BUFFALO RADIOLOGICAL SOCIETY *President*, John Barnes, M D, 875 Lafayette Ave., *Vice-president*, W L Mattick, M D, 290 Highland Drive, *Secretary-Treasurer*, J S Gian-Franceschi, M D, 610 Niagara Street Meetings second Monday evening each month

CENTRAL NEW YORK ROENTGEN-RAY SOCIETY *President*, W E Achilles, M D, 60 Seneca St, Geneva, *Vice president*, M T Powers, M D, 250 Genesee St, Utica, *Secretary Treasurer*, Carlton F Potter, M D, 425 Waverly Ave, Syracuse Meetings held in January, May, and October as called by Executive Committee

LONG ISLAND RADIOLOGICAL SOCIETY *President*, David E Ehrlich, M D, 27 W 86th St, New York City, *Vice-president*, H Koiransky, M D, 43-37 47th St., Long Island, *Secretary*, S Schenck, M D, 115 Eastern Parkway, Brooklyn, *Treasurer*, Moses Goodman, M D, 45-01 Skillman Ave, Long Island Meetings third Thursday evening each month at Kings County Medical Bldg

NEW YORK ROENTGEN SOCIETY *President*, E F Merrill, M D, 30 W 59th St, New York City, *Vice-president*, I W Lewis, M D, *Secretary*, H K Taylor, M D, 667 Madison Ave, New York City, *Treasurer*, R D Duckworth, M D, 170 Maple Ave, White Plains Meetings third Monday evening each month at Academy of Medicine

ROCHESTER ROENTGEN-RAY SOCIETY *Chairman*, Joseph H Green, M D, 277 Alexander

St , *Secretary*, S C Davidson, M D , 277 Alexander St Meetings at convenience of committee

SOCIETY OF RADIOLOGICAL ECONOMICS OF NEW YORK *President*, Albert L Voltz, M D , 115-120 Myrtle Ave , Richmond Hill, *Vice-president*, M M Pomeranz, M D , 911 Park Ave , New York City, *Secretary*, W F Francis, M D , *Treasurer*, Theodore West, M D , United Hospital, Port Chester Meetings first Monday evening each month at McAlpin Hotel

NORTH CAROLINA

RADIOLOGICAL SOCIETY OF NORTH CAROLINA *President*, Robert P Noble, M D , 127 W Hargett St , Raleigh, *Vice-president*, A L Daughtridge, M D , 144 Coast Line St , Rocky Mount, *Secretary-Treasurer*, Major I Fleming, M D , 404 Falls Road, Rocky Mount Meetings with State meeting in May, and meeting in October

OHIO

CLEVELAND RADIOLOGICAL SOCIETY *President*, North W Shetter, M D , Lakewood City Hospital, Lakewood, *Vice-president*, John Heberding, M D , St Elizabeth's Hospital, Youngstown, *Secretary-Treasurer*, Harry Hauser, M D , Cleveland City Hospital, Cleveland Meetings at 6 30 P M at Cleveland Chamber of Commerce Club on fourth Monday of each month from October to April, inclusive

RADIOLOGICAL SOCIETY OF THE ACADEMY OF MEDICINE (Cincinnati Roentgenologists) *President*, George Benzing, M D , St Elizabeth Hospital, Covington, Ky , *Secretary-Treasurer*, Justin E McCarthy, M D , 707 Race St , Cincinnati, Ohio Meetings held third Tuesday of each month

PENNSYLVANIA

PENNSYLVANIA RADIOLOGICAL SOCIETY *President*, Sydney J Hawley, M D , Geisinger Memorial Hospital, Danville, *First Vice-president*, William J McGregor, M D 744 Franklin Ave , Wilkesburg, *Second Vice-president*, Oscar M Weaver, M D , 12 S Main St , Lewistown, *Secretary-Treasurer*, Lloyd E Wurster, M D , 416 Pine St , Williamsport, *President elect*, Charles S Caldwell, M D , 520 S Aiken Ave , Pittsburgh Annual meeting, May, 1938 Exact date and place to be decided

PHILADELPHIA ROENTGEN RAY SOCIETY *President*, Thomas P Laughery, M D , Germantown Hospital, *Vice-president*, Elwood E Downs, M D , Jeans Hospital, Fox Chase, *Secretary*, Barton H Young, M D , Temple University Hospital, *Treasurer*, R Manges Smith, M D , Jefferson Hospital Meetings first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S 22nd St , 8 15 P M

RHODE ISLAND

See New England Roentgen Ray Society

SOUTH CAROLINA

SOUTH CAROLINA X-RAY SOCIETY *President*, Robert B Taft, M D , 105 Rutledge Ave , Charleston, *Secretary-Treasurer*, Hillyer Rudisill, M D , Roper Hospital, Charleston Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

MEMPHIS ROENTGEN CLUB Chairmanship rotates monthly in alphabetical order Meetings second Tuesday of each month at University Center

TENNESSEE STATE RADIOLOGICAL SOCIETY *President*, H S Shoulders, M D , 246 Doctors Bldg , Nashville, *Vice-president*, S S Marchbanks, M D , 508 Medical Arts Bldg , Chattanooga, *Secretary-Treasurer*, Franklin B Bogart, M D , 311 Medical Arts Bldg , Chattanooga Meeting annually with State Medical Society in April

VERMONT

See New England Roentgen Ray Society

VIRGINIA

RADIOLOGICAL SOCIETY OF VIRGINIA *President*, Fred M Hodges, M D , 100 W Franklin St , Richmond, *Vice-president*, L F Magruder, M D , Raleigh and College Aves , Norfolk, *Secretary*, V W Archer, University of Virginia Hospital, Charlottesville

WASHINGTON

WASHINGTON STATE RADIOLOGICAL SOCIETY *President*, H E Nichols, M D , Stimson Bldg , Seattle, *Secretary*, T T Dawson, M D , Fourth and Pike Bldg , Seattle Meetings fourth Monday of each month at College Club

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

FAMILY RECORDS

Those who heard the paper on "The Relation of Heredity to the Occurrence of Cancer," read by Dr. Maud Slye at the Cincinnati meeting of the Radiological Society, and have followed her work in the last quarter of a century, are bound to be impressed with the necessity for active, practical application of the results of her observations. Reduced to its simplest possible form, Dr. Slye's theory of heredity explaining both the occurrence of malignancy and its location is that there is one unit recessive genetic factor for each type of malignancy, carcinoma, sarcoma, and leukemic disease, and that there is also one unit recessive genetic factor for each location of malignancy, such as the breast, the stomach, or the lip. The occurrence of breast cancer, for example, would therefore require two unit recessive factors, one for malignancy of the epithelium and the other for its location in the breast.

If Dr. Slye's theory is sound, she should be able to breed carcinoma, sarcoma, leukemia, or any combination of them, into families of mice, and she should be able to control the location of these diseases. Furthermore, she should also be able to prophesy as to the number of cases of these different varieties of malignant diseases and their combinations to be expected in a given number of individuals, and she should be able to state not only what the mathematical expectancy of such tumors will be, but also where they will be located. This is exactly what she has done, and her mathematical demonstrations have corresponded so exactly with the theory that it must be accepted as proved. Rarely does a scientist succeed in reaching a prime goal with such completeness, and yet we must not permit close application to the minutiae of Dr. Slye's report to prevent us from fully appreciating the importance of her fundamentals, and the fact that this work has now assumed tremendous practical importance.

What is that practical importance? It is

that we should apply to human families these findings so that we may be able ultimately to breed cancer out of the human race as she has bred it out of mouse families, for what, in terms of human life, would amount to more than 3,000 years. This could be accomplished by the same amount of attention to the mating of individuals with cancer in their families as is now paid by intelligent persons to idiopathic epilepsy.

The first essential in such a project is the keeping of adequate family records. The task of keeping such records is a slow, painstaking, rather intricate procedure, but is not beyond the abilities of any physician sufficiently industrious and intelligent to practise his profession. Briefly, such records include the following data:

1. Hereditary data.
2. Data concerning the patient.
3. Data concerning the neoplasm as an entity.
4. Data bearing on the external cause of cancer in whatever organ it may occur.

This should supply scientific data, not only on the patient himself and his heredity, but also data concerning the external causative factors in every type of malignancy. It is real scientific research which is always difficult, but always worth while. Already, several county medical societies and at least one middle-western State medical society have established bureaus for keeping such records. Should we not, as individual radiologists and also as a great scientific organization, help to accomplish this fundamental work in the control of human cancer? At the moment there must be many members of the Radiological Society who are willing to undertake the labor of this scientific research, and to use their influence in establishing state and national bureaus.

ARTHUR W. ERSKINE, M.D.

SOME PROBLEMS CONFRONTING THE RADIOLOGIST TO-DAY¹

Within the short period of its growth no specialty of medicine has become such an indispensable part of the art of medicine as has radiology. Indeed, the science of radiology has caused such a change in the fundamentals of diagnosis and treatment relating to many branches of medicine that radiological procedures have become an indispensable prerequisite for the pursuit of many of these specialties. It is not difficult to imagine the chaotic state which would prevail in the diagnosis of orthopedic, gastro-intestinal, thoracic, and neurologic conditions if the advantages of the x-ray were suddenly made unavailable. So ramifying has the influence of this physical agent become that even the smallest hospital is now equipped with an x-ray machine and the modernization of the apparatus in many community hospitals is proudly acclaimed by the local press. With this rapid and sometimes wild development of such an important agent the problems that have arisen concerning those who would specialize in its use are quite logical ones. In addition, they are influenced somewhat by a so-called modern changing order of things that is being reflected in all parts of our community existence.

In the past radiology has been handicapped in the solution of some of its problems by the lack of any unified body that could act for, or represent with any authority, radiologists as a whole. With the formation during the past year of the Inter-Society Economics Committee, we have made a good start toward the solution of some of the problems that are continually arising regarding our work. Through the reports and bulletins of this Committee you have been apprised of the problems that confront it and what it has accomplished toward their solution. Our Society has assured this Committee of its continued support and during the past year we contributed substantially toward its financial needs. Within the last year the American Medical Association has reiterated its recognition of radiology as a specialty of medicine and emphatically concluded that it cannot be divided into professional and technical branches. Also of no little significance is the establishment by the American Hospital

Association of the principles of relationships between radiologists and hospitals. How closely these will be adhered to time alone will tell, but so far a dignified and commendable approach to the solution of some of our problems has been achieved. Regardless of how much is accomplished by these means, I believe that much can and should be accomplished through education—not only through the education of others but through the education of ourselves and those who will elect to pursue radiology as a specialty. Indeed, the entire future of radiology is intimately linked with the education of those who are to follow us and it is well to recall that it is a poor teacher whose students do not excel him.

Resolutions and rules will have little effect unless we can justify our position by the quality of our work and the efficiency of the service we render. The successful radiologist strives to keep abreast of the times and to know more about his field of endeavor than his colleagues who use the x-ray only incidentally in their practice. When this prevails, he will have become such an indispensable ally of his professional colleagues or institutional staff that there should be no question about the security of his practice. A specialty that has developed such ramifying interests as radiology demands constant study and opportunities for scientific discussion. Through the medium of our annual meetings and Journal these opportunities are provided. However, I believe that we should seriously consider some means of extending them as far as our own members are concerned. The formation of the American Board of Radiology and its qualifying examination has created a demand for so-called "refresher courses," and here at this meeting of the International Congress the instructional courses are filled to capacity. I thoroughly believe that the Radiological Society of North America could offer a real service to radiology and our members by providing at our annual meeting and at such other times and places as may be deemed advisable, short, well-planned, and timely instructional or refresher courses by representative radiologists. Such courses should be limited to members of the Society and a nominal charge made to defer the cost of preparing the material involved. The arrangement of these courses could well be a function of our Educational and Publicity Committee. The value of such forms of instruction has already been established by other specialists in

¹ Presidential address delivered at the Annual Banquet of the Radiological Society of North America, Chicago, Sept. 10, 1937.



RADIOLOGICAL SOCIETY OF NORTH AMERICA
PALMER HOUSE SEPTEMBER 16, 1937 CHICAGO

medicine, notably the ophthalmologists and oto-rhinologists

There are other ways in which the prestige of radiology may be enhanced by means of education. I refer now to a conservative educational program for the layman and fellow-practitioners concerning the usefulness of x-rays properly applied. The American Medical Association, the College of Surgeons, various State medical societies and other organizations have done much to stimulate the interest of the layman in his state of health through the means of popular articles, radio broadcasts, educational films, public meetings, etc. I believe that there is a real opportunity for our Society to do likewise in the interests of the general public and radiology.

Last year your Executive Committee investigated the cost of producing a high quality educational moving picture film that would portray to lay audiences in an ethical and conservative manner the value of radiological procedures. The expense of producing such a film proved beyond the budget of our Society and the idea was temporarily abandoned. Through such means and many others at the disposal of our Educational Committee the general public may acquire a greater appreciation of the value of x-rays as related to their own health and the practice of medicine. When the average layman learns that the proper application of x-rays is something more than the taking of a picture, his conception of a radiologist will change from that of a glorified photographer to that of a dignified specialist of medicine. In our everyday contact with patients we as radiologists can do much to enhance the prestige of our specialty. This cannot be done when patients are seen only by our technical assistants. We should not lose sight of the fact that we are consultants in medicine and a personal contact with all our patients and a sympathetic interest in their aches and pains will do much to assure them that they are paying for a physician's opinion rather than a snapshot of some part of their anatomy. The casual interest of some radiologists in their patients and the institutions which they serve is in no small way responsible for the desire in some quarters to dispense with the need of a radiologic consultant. The practice of radiology is the practice of medicine and it behooves us to conduct our work and our treatment of patients accordingly. We are not without fault in some of the problems that confront us but many of these may be overcome and the prestige of radiology

increased if we will adhere to the ideals and purposes of our specialty. The effect of an educational program for ourselves, fellow-practitioners, and laymen will be infinitely more permanent and will more assuredly secure the place of the radiologist as an indispensable specialist of medicine than resolutions and agreements which are easily modified to suit the whims of those who may be in power.

JOHN D. CAMP, M.D., *President*
Rochester, Minn.

ANNOUNCEMENTS

PRESENTATION OF GOLD MEDAL
AWARD TO GEORGE W.
HOLMES, M.D.

By JOHN D. CAMP, M.D.

Ladies and Gentlemen: It is now my honor and privilege to present the highest award of our Society—an award that we consider the most distinguished in the field of Radiology in America—the Gold Medal of the Radiological Society of North America. We have chosen for this award one whose contributions to scientific radiology are of world-wide renown, one whose eminence in the field of education in radiology is unchallenged, and one who was a pioneer in the development of the tumor clinic as a scientific means for the study and treatment of cancer and neoplastic disease.

This Gold Medal has been awarded to a small and distinguished number of physicians and physicists, all leaders in the field of radiology during the past thirty years. It shares, by such association, in the gentle lustre shed by these great men, and with the passing years has taken on the additional distinction of being the award of the largest radiological society in the world.

Doctor George Winslow Holmes, we present to you the Gold Medal of the Radiological Society of North America.

FIFTEENTH ANNUAL MEETING
OF THE ACADEMY OF
PHYSICAL MEDICINE

Philadelphia, Oct. 19, 20, 21

The Fifteenth Annual Meeting of the Academy of Physical Medicine will be held at the

Hotel Walton, Philadelphia, Oct 19, 20, 21, 1937 The Academy, which is international in scope, will present a scientific program based on reports of the most recent research and practice of the various specialties In addition to the lectures, demonstration clinics will be held at the hospitals of the University of Pennsylvania, Jefferson Medical College, and Temple University

A copy of the program may be had by addressing William D McFee, M D, Chairman, Committee on Program and Publication, 41 Bay State Road, Boston, Mass

extensive study of roentgenology, studying under men in Buffalo, New York, and Boston At the time of his death, he was attending roentgenologist at Our Lady of Victory Hospital, Lackawanna, N Y, and Mercy Hospital, Buffalo, N Y He had been on the staff of Our Lady of Victory Hospital since 1921 and of Mercy Hospital since 1923

Dr Cotter was a member of the American Medical Association, the Medical Society of the State of New York, Medical Society, County of Erie, the Radiological Society of North America, and the Buffalo Radiological Society

AMERICAN ACADEMY OF ORTHOPEDIC SURGEONS

The first West Coast meeting of the American Academy of Orthopedic Surgeons will be held January 16-20, 1938, at the Hotel Biltmore, Los Angeles Special trains will be run, with stop overs at Santa Fe, the Grand Canyon, San Francisco and other points For further information write to Robert L Lewin, Hotel Biltmore, Los Angeles, California

CORRECTION

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I S TROSTLER, M D

IN MEMORIAM

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ARCHIVOS DA FUNDACAO GAFFREE E GUINLE
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CANCER (DIAGNOSIS)

Heredity of Cancer Jules Bauer *Le Cancer*, 1935 12, 238-250

In spite of the importance of exogenous etiologic factors the etiology of cancer is unquestionable. This has been proven by experiments on spontaneous or grafted or artificially produced tumors of animals by clinical experiments and by a few statistical researches on human cancer. Experiments on tumors in univitel-line twins confirm this opinion.

The localization of cancer in a particular organ can be shown by the incidence of multiple cancers in one family.

Two genotypical factors form the constitutional basis of cancer, one responsible for a general tendency to produce neoplasms the other determining the location in a particular organ. We have then a system of dihybrid heredity, two couples of allelomorphic characters. It may be deduced, therefore, that if both parents have suffered from a cancer of the same organ, then 50 or 100 per cent of their offspring will be similarly afflicted. If both have cancer but of different organs the children's chances for escape are much better—the same as of those with one cancerous parent.

Exogenous factors may participate in the etiology of cancer in reinforcing or even replacing either the general constitutional factor or the localizing factor.

S RICHARD BEATTY, M D

CANCER (THERAPY)

Teleradium Therapy E Maier *Strahlentherapie*, 1937, 58, 593

The author describes his apparatus for teleradium therapy consisting of one 400 mg and one 3 gram applicator. Following a brief discussion of the physical data he reports some of the results obtained in the treatment of cancer. Since 1931, there were 1,204 patients seen and 840 of these were treated with the 3-gram bomb. Among those were 120 cases of carcinoma of the tongue, 66 could be observed for a period of three years. Twenty of these patients are free from symptoms. The author believes that teleradium therapy is not to be considered as competition to roentgen therapy but has its very own field of usefulness and should be applied according to definitely established indications.

ERNST A POHLE, M D Ph D

Roentgen Therapy of Carcinoma Protracted Fractional Daily Exposures and Exposures in Periodical Series H Coutard *Strahlentherapie* 1937 58, 537

Following a brief discussion of the well known principles of the fractional dose method, Coutard discusses the conception of periodicity as a possible directing factor in the roentgen therapy of cancer. A survey of his clinical material of the years 1920-1929 showed that series given from 13 to 17 days from 24 to 29 days and

from 39 to 41 days showed the best results. The difference was high enough to be significant. He considers four principal factors of importance in the treatment of undifferentiated and differentiated types of carcinoma. For the undifferentiated type they come in the following order: (1) distribution in the tissue, (2) total dose, (3) time factor, and (4) daily dose. For the highly differentiated carcinoma they change as follows: (1) distribution of intervals between series, (2) daily dose, (3) distribution in the tissue, and (4) total dose.

ERNST A POHLE, M D, Ph D

Continuous and Discontinuous Roentgen Therapy of Cancer at Long Distances and with Low Intensities "Superteleroentgentherapie" G G Palmieri *Strahlentherapie*, 1937, 58, 603

In the author's institute two x ray tubes have been installed on the first and third floors. On the second floor are four chambers with four beds. The distance between the targets of each tube and the beds is from 3.5 to 4 meters. Patients can be exposed continuously at these long distances with about 0.25 r/min. The average daily dose used so far amounts to 200 r given in 13½ hours which is usually applied in three series of 4½ hours each. The skin tolerates large doses under these conditions, epidermolysis does not occur until 5,000 to 5,500 r have been applied. Occasionally the total doses reached 8,000 r without serious effects. The author promised to report his results at the Fifth International Congress in Chicago.

ERNST A POHLE, M D, Ph D

THE COLON

Attack of Partial Occlusion Due to Diverticulitis in a Case with Diverticulosis of the Colon and Diverticulitis of the Sigmoid Gondard and Blanc *Bull et Mém Soc Radiol Méd de France* February, 1937, 25, 28-29

A patient who had suffered an attack of acute abdominal pain, with evidence of partial obstruction and a mass in the pelvis was demonstrated to have numerous diverticula of the colon associated, in the sigmoid, with an irregular constriction.

S RICHARD BEATTY, M D

CONTRAST MEDIA

The Barium Enema in Intestinal Intussusception of Children P Lamarque and P Betoulières *Bull et Mém Soc Radiol Méd de France*, 1937, 25, 29-31

The authors believe the barium enema with fluoroscopic and radiographic observation to be very useful in the diagnosis of intestinal intussusception in children, and in locating the site prior to laparotomy. They have used never more than one meter of pressure and have had no accidents.

The barium enema makes possible an early and more certain diagnosis. The picture is characteristic in intussusception of the colon or ileo-colic intussusception. The enema is useless in lesions higher, except in excluding these types.

The therapeutic results of reducing the intussusception have not been observed in the six cases reported, as all were subjected to surgery. Unquestionably the use of the barium enema has resulted in a much lower mortality.

S RICHARD BEATTY, M D

THE CRANIUM

Roentgen Signs in Hydrocephalus and Their Diagnostic Value. M B Kopylov. *Am Jour Roentgenol and Rad Ther*, November, 1936, 36, 659-673.

The variations in the skull changes in this condition can be explained by consideration of the physiological factors, the peculiarities due to age, the type of skull and its parts, and the part played by hydrodynamics. Thus an open hydrocephalus with fluid in the subarachnoid must produce changes different from the closed, in which the subarachnoid spaces are dry and the convolutions of the brain can press directly on the bones. In like manner other changes found can be explained.

The principal roentgen signs in the open are as follows. Sella turcica in children shows no change but in adult at later stages becomes cup shaped, the sutures often distended and in children the dentations at the sutures elongated. The child's skull is smooth and round or spherical with increased radius of vault and fossæ.

In the closed type the changes in the sella turcica depend on whether the closure is of the upper (region of sylvian aqueduct), or lower type (region of fourth ventricle). In the lower, the posterior clinoid process inclines anteriorly, the dorsum is atrophied, shortened, or bent anteriorly, the entrance is widened very slightly and the floor is deepened chiefly in the back part. In the upper, the posterior clinoid process and the dorsum become straightened and inclined posteriorly. The anterior aspect of the dorsum is atrophied. Entrance is more extended and the floor more evenly deepened than in the lower.

In both types of the closed, the digital impressions and vessel grooves are deepened, the sutures are often distended but the general skull configuration is not definitely abnormal.

S M ATKINS M D

EPILATION OF SCALP

The Depth Dose during Epilation of the Scalp by Irradiation. A. Proppe. *Strahlentherapie* 1937, 59, 139.

The author determined the dose reaching the brain during irradiation of the scalp for epilation. A small

ionization chamber was inserted in a skull after it had been filled with paraffin. Roentgen rays produced at 85 kv and filtered through 0, 0.5, 1, and 2 mm Al, respectively, were used. If four fields are applied, a dose of 70 per cent of the surface dose reaches the brain substance in the depth. For an epilation dose effective in the skin of 400 r, this amounts to 280 r within the brain. If five and six fields are used, this dose increases materially, of course. The author concludes from his studies that not more than four fields should be used for epilation of the scalp, preferably according to the technique described by Schreus.

ERNST A. POHLE, M D, Ph D

GALL BLADDER (NORMAL AND PATHOLOGIC)

Interpretation of Roentgen Films in Gall bladder Diseases. Hermann Durst. *München. med. Wchnschr.*, June 11, 1937, 84, 932-934.

The author states that there is always more or less error in the diagnosis of gall bladder films, there being poor correlation between the roentgen and operative findings. He therefore undertakes a comparison of these findings in his own cases which have been operated upon.

In 53 cases of stone, 27 were diagnosed by x-ray the gall bladder being visualized, six cases showed no emptying of the gall bladder.

In 12 cases of chronic inflammation six showed visualization with non-emptying, four no visualization.

Of all these, 52 in the first group showed colic while all but two in the second did not. The latter group showed other symptoms as well. While there is some uncertainty about the use of colic as a sole criterion for operative intervention, careful history will usually distinguish stone from other colic. The various combinations of roentgen findings and colic are considered to have different meanings which are set out in a tabulation.

The author considers the oral method unreliable, and uses only intravenous administration. False emptying may be caused by egg yolk given the night of administration or by the injection of hypophysin. (Abstractor's note. The opinions of the author contrast so violently with the findings of workers in the United States, especially at the Mayo Clinic, that one would question them. The evidence given for them seems very inadequate.)

LEWIS G. JACOBS M D

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Radiologic Studies of Diverticula of the Digestive Tract below the Diaphragm. J. Baumel and J. Balmes. *Bull. et Mém. Soc. de Radiol. Méd. de France*, January 1937, 25, 31-44.

Briefly reviewing the pathologic anatomy, etiology and localization of diverticula of the intestinal tract

below the diaphragm, the authors stress the necessity of careful roentgenologic technic in the attempt to demonstrate these conditions

The technic used should be adapted to that portion of the gastro-intestinal tract in which the diverticula are sought. In the stomach, examination with a small meal from several angles, including the Trendelenburg position, is essential. Frequently the introduction of barium into the duodenum through an Einhorn tube is of value, in that the shadow of the filled stomach is avoided.

Barium or one of the flocculent solutions by mouth, followed by frequent fluoroscopy or roentgenography, is the method of examination for the small bowel.

In the case of the large intestine, three opaque meals at 20, 40, and 8 hours before roentgenography may be used. Enemas of barium or of flocculent material, with small amounts of solution, or with complete filling and films taken before and after evacuation and after insufflation of air, are perhaps more useful in the study of the large intestine.

The details of technic, the diagnosis and the differential diagnosis of diverticulosis and diverticulitis, are discussed in detail.

S RICHARD BEATTY, M D

MYOSITIS OSSIFICANS

Myositis Ossificans. C. Artus-Christiani. Lyon Chir., January-February, 1937, 34, 5-19. (Reprinted by permission from British Med. Jour., April 10, 1937, p. 57 of Epitome of Current Medical Literature.)

The author discusses the history and pathology of myositis ossificans and describes two personal cases of the disease. Traumatic myositis ossificans is an intramuscular bony formation which appears some time after the original injury. The trauma may be an external injury, a fracture or dislocation, or a sudden muscular contraction. On the other hand, slight repeated traumas may give rise to the disease in the thigh in cavalry soldiers, and in the biceps or in the muscles of the arm or shoulder following excessive exercise of these upper arm muscles. Ossification never arises in the muscles of the hand. It is most often seen in young persons of the male sex. The thickening of the muscle usually occurs soon after the swelling caused by the injury, and may be overlooked unless there is limitation of movement or pain or an x-ray film is taken. The growth may be joined to the bone by fibrous tissue or may be isolated in the muscle. It may vary in size from the thickness of the thumb to 20 cm.

The first case described was in a man 66 years of age who in falling had fractured the right femur. The leg was put in extension and immobilized for three weeks. As a radiograph then showed that consolidation had not taken place and as reduction was not possible owing to a muscular growth, operation was carried out. This showed a hematoma with myositis ossificans extending into the vastus and adductor muscles. Osteo-

synthesis was performed, but the patient died two days later from paralytic ileus, shock, and uremia. In the second case the tumor appeared in a man 23 years of age following a kick on the thigh from a horse. The growth increased in size until, at the end of three months, the knee function was affected. Operation was carried out and the tumor, which was of bony consistency, was successfully removed.

PEPTIC ULCER

'Niche en Plateau' Due to Ulcer. A. Lacroix and A. Blondeau. Bull. et Mém. Soc. Radiol. Méd. de France, February, 1937, 25, 158-162.

The large, flat based niche is usually regarded as pathognomonic of gastric carcinoma. The authors present a case demonstrating an exception. A typical "niche en plateau" in an old woman, with symptoms suggesting malignancy, was observed radiologically to show marked decrease in size after three weeks' ulcer treatment and complete healing in six weeks. Such niches require a period of observation under strict treatment before a definite diagnosis can be made.

S RICHARD BEATTY, M D

The Radiologic Differences in the Course of Gastric and Duodenal Ulcer. R. A. Gutmann, Parturier-Lannegrace, and Piquet. Arch. d. mal. de l'app. digestif, March, 1937, 27, 324-326.

An important difference between gastric ulcer and duodenal ulcer is that, while the latter heals often with scarring and deformity, the former does not, consequently, it is sometimes impossible to state whether a lesion in the bulb is active or inactive. The presence of a niche in the stomach denotes activity.

S RICHARD BEATTY, M D

PHLEBITIS

The Roentgen Irradiation of Acute, of Sub-acute, and of Chronic Phlebitis and Thrombophlebitis. C. Henschen and F. Becker. Schweiz. med. Wchnschr., May 15, 1937, 67, 438-441.

The authors reviewed some literature on the irradiation of acute, sub-acute, and chronic phlebitis and thrombophlebitis, but found surprisingly little material published. A series of their own cases is reported, rather small in number. However they are encouraged by it to the further use of the method. Good results are reported in the literature in the regression of papilledema from venous thromboses of various sorts. The authors then describe the findings in phlebitis, and state that proper treatment initiates a prompt clearing of the pathologic process. Epidemics of phlebitis differ among themselves, some showing a seasonal epidemic form in which all cases of operation may be infected. This form sometimes leads to a chronic recurring type of long duration.

In the treatment of the different forms of phlebitis there are a great many methods. Applications of alcohol, of aluminum acetate, lead water, etc., iethyol compresses, camphorated ointment of 10 per cent methyl silicate, intravenous injections of argyrol, immobilization, bandaging, galvanization, thermal treatment diathermy and the use of massage, diet, either salt free or low calorie, urotropin by mouth or intravenously, theobromine, witch hazel, injection of 10 c.c. of 1 per cent novocaine in the lumbar sac, high frequency current, ultra violet or infra red rays surgical excision, removal of the clot and subsequent suture, fixation abscess, protein shock, anti streptococcic serum, polyvalent vaccine, etc., may be used.

The rule is stated that the control of epidemic cases should be through the seeking out through a possible isolation of occasional cases and the search for a vaccine against phlebitis. The action of the rays is considered to be due to a number of interlocking effects. These are both local and general, and are given in very considerable detail. These effects are mostly accompanied by citations to the authors, no original work having been done along these lines. Among the more outstanding clinical effects are the shortening of the course of the disease. The authors believe that roentgen therapy is indicated not only in the superficial structures but also in those of the deeper structures such as the pelvis mesentery and the skull. Concerning technique, they believe that the more acute the infection the weaker the irradiation. The basic dose lies between 100 and 200 roentgens the actual dose given, however, is varied each time according to the condition of the patient. The irradiated area should in all cases cover the entire inflamed area.

L. G. JACOBS, M. D.

PLANIGRAPHY

Planigraphy I—Introduction and History J. Robert Andrews. *Am Jour Roentgenol and Rad Ther*, November, 1936 36, 575-587.

Planigraphy is a method of roentgenographic projection of plane sections of solid objects and is effected by moving the film and roentgen tube in opposite directions simultaneously in a constant ratio by means of a connecting system which rotates about an axis that lies in the plane of the section to be projected.

The principle of body section was first described by Bocage, of France, in 1921, and since then other methods have been described by other authors, notably Kieffer, of Norwich, Conn. who discovered this principle independently in 1929. Grossmann's apparatus now manufactured in Germany, goes under the name "Tomography."

Chaoul claims that pulmonary vessels, their divisions, the bronchi and their related pathological conditions, cavities and spread of lung disease, can be demonstrated more clearly in this manner than by any other method.

S. M. ATKINS, M. D.

Note on Pulmonary Planigraphy Delherm, Jacques Bernard and Nguyen Dinh Hoang. *Bull. et. Mém. Soc. Radiol. Med. de France* 1937, 25, 123-125.

It is somewhat early to make definite statements as to the relative value of planigraphy. Certainly the major reliance in study of the lung must be placed in conventional radiography and stereo-radiography. Planigraphy furnishes a method of analysis of complex images. Frequently the interpretation is difficult. Their value as an aid in diagnosis is unquestioned as it has been possible to better define such lesions as cavities and even to demonstrate cavities hidden in the usual roentgenogram by extraneous opacities.

S. RICHARD BEATTY, M. D.

PNEUMONIA

Lobar Pneumonia in Childhood S. L. Ellenberg and A. T. Martin. *New York St. Jour. Med.*, Jan. 15, 1937, 37, 119-127. (Reprinted by permission from *British Med. Jour.*, April 10, 1937, p. 59 of *Epitome of Current Medical Literature*.)

The authors record a clinical survey, covering five and one-half years of 459 cases of lobar pneumonia in childhood. Of these cases, 50 per cent arose in children under the age of four years and only a few in the later ages of ten and upwards. The peak incidence was reached in the first years of life. The greatest number of cases were recorded during the late winter months of March and April while the fewest cases arose in July. The mortality in this series was 8.6 per cent, and this could have been reduced still further by an earlier admission to hospital, as many children were sent in as a last resource. This mortality rate compares favorably with the records of other writers. The fact that the mortality is higher in children two years of age and under is also borne out by this study, for the mortality in this age group is 24 per cent as compared with a mortality of 2.1 per cent in the age group above two years. X-ray examination was useful and confirmed the diagnosis of lobar pneumonia in most cases. Meningeal irritation was noted in 24 cases and lumbar puncture showed increased pressure but no excess of cells and no organisms. The five most frequent complications were otitis media, empyema, meningismus, furunculosis and abscesses. Empyema was the most serious complication and the one most likely to influence the course of the illness. Treatment consisted in the main in leaving the patient alone and in good nursing. Abdominal distention needed to be carefully watched and treated with enemas at once. Oxygen is considered to be a very definite adjunct to the treatment of pneumonia, and should be used whenever cyanosis, excessive restlessness, or severe toxemia is present. The old method of giving oxygen by the open method or through a nasal catheter is condemned as being of no value. The oxygen tent only was used and proved of much value.

PNEUMOTHORAX

Spontaneous Pneumothorax from Pulmonary Metastasis of an Osteosarcoma M J De Barrin. *Bull et Mém Soc Radiol Méd de France* January, 1937, 25, 73-76

A year after primary irradiation of an osteosarcoma of the pubic bone and during the course of a second series for local recurrence, a patient developed clinical evidence of pneumothorax. The chest film showed complete pneumothorax on the left, with fluid in the sulcus and large metastatic nodules in the other lung. Two months later films showed persistence of the pneumothorax, with absorption of the fluid. The patient died 18 months after diagnosis of the lesion. Presumably the pneumothorax was the result of rupture of the pleura by a small metastatic nodule.

S RICHARD BEATTY, M D

RADIATION INJURIES

Dangers of Introduction of Radio-active Substances into the Body S Laborde *Presse méd*, Nov 25 1936, pp 1915-1918 (Reprinted by permission from *British Med Jour*, Jan 30, 1937 p 19 of *Epitome of Current Medical Literature*)

The author warns against too high dosage in oral or other administration of radio-active substances. In general the quantities should not be in excess of those which are ingested in naturally radio-active springs, and it should be remembered that short lived radio active substances such as mesothorium and thorium-X are at least as dangerous as the others. It is a matter of surprise that repeated doses of from 50 to 300 microgrammes of thorium-X such as are sometimes injected in treatment of painful articular affections are not more often followed by toxic effects. These may be lethal and include acute enteritis, hematemesis, necrosis of the jaw, leukemia, grave anemia and local radiodermatitis coming on from one month to nine years after treatment. They are less frequent than among professional workers with radio-active substances but are nevertheless to be feared especially in those with idiosyncrasy.

Diseases Caused by X rays and Radio-active Substances S Laborde and J Leclercq *Écho méd du Nord* Nov 8 1936 6 797 (Reprinted by permission from *British Med Jour*, Jan 31, 1937, p 19 of *Epitome of Current Medical Literature*)

The authors give details of those diseases which are caused by x-rays or radio-active substances and which are considered to be occupational as they occur during medical or commercial work. The laws of compensation vary in the different countries, and particulars are given which show the diseases and occupations entitling the worker to compensation in France. The first of these diseases is radiodermatitis, which is easy to diagnose and is seen chiefly in workers who come in

contact with tar or paraffin. Skin cancer may develop later in these cases. Cancer of the lung occurs in miners who extract pitchblende, but as there are no mines in France where radio-active substances are found, this is not in the list of compensatory diseases. Various conditions of the blood, such as anemia with leukopenia, pernicious anemia, and leukemia, are caused by x rays, and these are included in the list. Sterility and complications of pregnancy cannot be proved to be due to these causes as there may be other factors present, and these disorders are not yet included in France. On the other hand necrosis of bone, particularly of the jaws, can be shown to be the result of work with radio-active products which entails putting these substances in the mouth. Details of the rules which govern compensation are given and the question of protection is discussed.

Recommendations suggested include working for not more than seven hours a day for five days a week with at least one month's holiday a year. Those persons who work in the x-ray department should be particularly healthy and should have no other hospital work. For protection, the operator should be as far as possible from the x ray apparatus and should never be exposed to direct rays. The x ray tube should be protected by a lead screen. The worker who extracts radio-active substances should be given adequate protection. Protection against the beta ray is easy and only necessitates handling the preparations with wooden pincers. Against the gamma ray protection must be by means of a lead screen, but is of necessity so difficult that the number of persons dealing with this type of ray should be as numerous as possible so that the time spent in contact should be shortened in each individual case.

Late Injuries Due to Radiation and Appearing Following Trauma W Schloss *Strahlentherapie*, 1937, 58, 697

The author has studied the relation between trauma and late injuries in previously irradiated tissue. He briefly reports five cases illustrative of this group. In one patient the trauma was of a mechanical nature. In another case it occurred because of additional radiation due to a mistaken diagnosis of recurrence and in another case mechanical and pharmacotoxic trauma were combined. He emphasizes the necessity of drawing the attention of our patients to the possibility that injuries after irradiation may develop even years following the exposure and that irradiated tissue should be protected from all irritation.

ERNST A POHLE, M D, Ph D

RADIUM

Early Experiences with Radium Curtis F Burnam *Am Jour Roentgenol and Rad Ther*, October, 1936, 36, 437-452

This article, the Janeway Memorial Lecture, in a reminiscing way tells of the author's experiences in

procuring and applying radium in Baltimore during the years of 1911-1916, and of the acquaintances and friendships developed with others similarly engaged in studying the field of usefulness of radium in its several forms. The development of experimental and clinical knowledge of radium therapeutics is traced and some of the results obtained in those years briefly reviewed.

J E HABBE, M D

The Production of Mutations by Beta Rays of Radium in the Fruit Fly. K. G. Zimmer, H. D. Griffith, and N. W. Timofeeff Ressovsky. *Strahlentherapie*, 1937, 59, 130.

The authors describe in detail their experimental procedure for the production of mutations in the fruit fly by means of beta rays of radium. A special ionization instrument was constructed which permitted the determination of the doses applied in r. The rates of mutations were directly proportional to the dose and were identical to those produced by equivalent doses of roentgen and gamma rays. In a graph the authors plot the mutation rate and the dose in r for beta rays, Grenz rays, roentgen rays, and gamma rays—there exists linear relation.

ERNST A. POHLE, M D, Ph D

Radium Therapy of Uterine Fibroids. R. Gauducheau. *Jour Radiol Electrol*, January, 1937, pp 1-4 (Reprinted by permission from the *British Med Jour*, May 8, 1937, p 75 of *Epitome of Current Medical Literature*).

The author considers x ray therapy to be the treatment of choice of uterine fibroids. However, in a limited number of cases it may be advantageous to use radium therapy instead. Radium therapy is indicated in cases in which transportation of the patient presents difficulties, or in which patients are very anxious to get through the treatment in the shortest possible time. The results of such therapy are probably just as good as those of x ray therapy, but radium therapy presents certain dangers, such as septic uterine complications, phlebitis, and pelvic peritonitis. The author had one fatal complication among 29 cases treated with radium, but over a number of years no complications have followed x ray therapy.

Studies of the Radiation Intensity around Radium Applicators by Means of Ionization Chambers with Thin Walls. H. Smereker. *Strahlentherapie*, 1937, 58, 267.

The author describes a cylindrical ionization chamber made of aluminum 0.01 mm thick which permits ionization measurements close to radium applicators by practically avoiding the wall effect. The results of her experiments in air are described with special consideration of the influence of size and thickness of filter as well as the distance. Comparing the results of her measurements with those obtained by means of an ionization chamber with thick air walls, differences as

high as from 60 to 70 per cent were found. With her chamber the author determined the equivalent of 1 mg-hr at 1 cm distance with 0.5 mm Pt filter at 774 r. She also discusses the experimental determination of Eve's constant (this constant is the number of ion pairs produced in 1 c.c. of air per second by gamma rays from radium C in equilibrium with 1 gram of radium provided there is a point source of radiation at 1 cm distance). She states that the inverse square law can not be used in calculating Eve's constant.

ERNST A. POHLE, M D, Ph.D

Limitations of Radium Therapy in Cancer of the Cervix. Palmer Findley. *Am Jour Roentgenol and Rad Ther*, October, 1936, 36, 457-460.

The author, a gynecologist, states that radium is used in preference to surgery in about 10 per cent of all of his gynecological cases, about 25 per cent of all uterine fibroids, 100 per cent of all so-called essential hemorrhages from the uterus not responding to medical measures, and 100 per cent of all cervical cancers being treated by this method. In the field of malignancies he has found only about 25 per cent five-year cures for cervical cancer, which fact prompts him to urge the widespread removal of pre-cancerous lesions of the cervix by trachelorrhaphy, amputation, and cauterization.

In considering the five- and ten-year end results in therapy of the uterine cervix, the difficulties in accurately grouping cases according to extent of involvement when first seen, is emphasized. It is also impossible to predetermine which patients will react hypersensitively to treatment, and which sluggishly. The undernourished, anemic individual, particularly if harboring infection, must be treated with caution and the debilitating factors eliminated whenever possible. Radium should be promptly removed at any sharp rise in temperature. The application of the x ray pelvic cycle will go far in preparing the field for radium. In cases of cancer of the uterine cervix occurring in the pre-menopausal group it is important by one means or another to exclude pregnancy before starting irradiation therapy. If pregnancy is found it should, of course, be interrupted and at least a week of time allowed to elapse before starting irradiation.

J E HABBE, M D

Radiation Therapy of Skin Cancer with Special Consideration of the Radium Technique. R. Müller. *Strahlentherapie*, 1937, 59, 45.

The author discusses the use of x rays and radium in the treatment of advanced carcinoma of the skin. He prepares special radium molds filtered through 0.1 mm Au containing from 3 to 3.5 mc per sq cm of surface, which are applied for a period of seven days. Some large tumors are taken off with the endotherm knife and radium is then applied to the base. For large lesions applicators are prepared consisting of screens 1.4 cm long and 0.4 cm thick filtered through 1.2 mm Pt. Instructions for arranging these screens at various

distances from the skin are given. Some lesions respond well to roentgen therapy (180 kv, 0.5 mm Cu, 23 cm FSD, 7 x 600 r applied every other day). The Coutard method does not seem to give very satisfactory results in carcinoma of the skin.

ERNST A. POHLE, M.D., Ph.D.

Qualifications for the Practice of Radium Therapy
G. W. Grier. *Am. Jour. Roentgenol. and Rad. Ther.*, October, 1936, 36, 453-460.

There is a similarity between the specialties of radium therapy and surgery in that in each, a specific form of treatment (radium in one instance and the knife in the other) is used in all cases actively handled by the practitioner. However, in the case of surgery, it is now well recognized by the medical profession and the public alike that adequate post-graduate instruction is essential, but in the case of radium therapy there is little recognition as yet of the importance of similar special training.

There are to-day three classes of practitioners who have a legitimate right to use radium. These are (1) the radium specialist who confines his practice to the use of radium, (2) the radiologist who applies radium as an adjunct to the x-ray, and (3) the several clinical specialists who, in treating certain diseases belonging naturally to their specialties, must include radium applications if they are to treat certain cases most effectively.

It is probable that with improved standards of post-graduate instruction being demanded by all the special examining boards, the extended period of post-graduate instruction will permit of adequate teaching of radium therapy. However, since the Council on Medical Education and Hospitals has classified radium therapy as a branch of radiology, it would seem proper that the therapeutic radiologist should also be competent and experienced in radium therapy.

J. E. HABBE, M.D.

Radio-active Emanation Therapy in Orselina.
H. Bodmer. *Schweiz. med. Wchnschr.*, May 8, 1937, 67, 408-410.

The paper discusses the natural emanation of the region near Orselina in the region of Upper Lake of Lucarno. The region is built up of crystallized rock especially a mica-bearing paragneiss characterized by a pegmatite form. Among the pegmatites are inclusions of granite extending easterly. In the mica-bearing rock there can be microscopically demonstrated with low magnification small radio-active particles of uranium, radium and of thorium. This renders the neighboring waters radio-active. The radio-active content of the water is from 18 to 30 Maché units per liter. These waters have been used for bathing for years. The radon content of the free air varies between one and three Maché units per liter. In the treatment chamber the basal air carries in the neighborhood of five or over Maché units per liter. With regard to

therapeutic use the author feels that this type of therapy has been unduly discredited by quackery and by the dangers to the blood-forming organs in the past, but that now the time has come to publish again concerning intelligent use under adequate control. The author distinguishes between weak therapy with naturally occurring emanation and strong therapy with artificially prepared emanation. The former produces reversible functional changes in the cell, the latter irreversible changes. The actual use of the latter is purely empirical, experiments being insufficient to give any reasonable basis for its employment. The treatment is used in sub-acute or chronic rheumatism or rheumatoid arthritis, or sub-acute and chronic muscular rheumatism, myalgia, neuralgia, and neuritis, gout, hypertonic states, a considerable number of skin diseases, roentgen ulcer, and certain diseases of the adnexa.

The therapy takes the form of baths with radio-active water of about 50,000 Maché units in 200 liters of water, of ingestion of 10,000 Maché units in 50 g of water, of inhalations in the "Emanatorium" of air usually containing 5 Maché units per liter, or in the application of finely pulverized clay in oil. Very great individualization of dosage is required. There is usually a general and local reaction consisting of slight vertigo, a tired feeling, physical and psychic unrest, sleeplessness, and increased pain in the arthritic joints. In gout a larger dose usually brings about relief of pain. In addition to the radiation in such cases an optimum general environment is required. Orselina has the advantage of optimum all round climate near a good source of radio-active emanation.

L. G. JACOBS, M.D.

ROENTGEN SICKNESS

Radiation Sickness. Its Possible Cause and Prevention.
Harry F. Friedman and Philip Drinker. *Am. Jour. Roentgenol. and Rad. Ther.*, October, 1936, 36, 503-509.

The authors report the results of control of radiation sickness by means of a mask which accomplishes deionization of the air which the patient breathes while in the treatment room. It was shown by experiments by Dessauer that individuals kept in a room of high concentration of positive ions would develop symptoms similar to radiation sickness. Experimental work was next carried out by Yaglou and one of the authors (P.D.) to determine the concentration of positive and negative ions six feet from an operating roentgen tube. From laboratory experiments it was next shown that the ion content in the therapy room was vastly in excess of the normal. These experiments suggested that roentgen sickness is the result of the combined effect of some extraneous factor breathed in by the patient plus the tissue changes effected by the x-rays. It appeared that either factor alone without the other would not produce true roentgen sickness in the usual therapeutic doses.

Twenty-four patients who were receiving high voltage x ray therapy in protracted manner upon utilizing the deionizing mask perfected by the authors were relieved of roentgen sickness in 92 per cent of the cases

The deionizing agent in the cartridge of the mask may be either charcoal or a wire cloth of very fine mesh

J E HANBE, M D

THE SINUSES

Accessory Nasal Sinusitis in Childhood, with Record of Bacteriological Examinations J Crooks and A G Signy Arch Dis Childhood, December, 1936, 11, 281-306 (Reprinted by permission from British Med Jour, April 10, 1937, p 58 of Epitome of Current Medical Literature)

The authors state that in view of the prevalence of infection of the nose, throat, and ears in childhood it is reasonable to suppose that disease of the nasal sinuses is common in early life. One hundred instances of nasal sinusitis are recorded and analyzed. Any or all of the accessory air sinuses may be diseased in childhood, for these are all present in early life. The development of the sinuses and the scheme of investigation are described. The presence of inflammatory exudate in an air sinus is proved by aspirating fluid from the cavity and not by washing it out of the nose with a cannula in the sinus. Reasons which led to a decision to aspirate the antra in a series of children undergoing removal of tonsils and adenoids were that they had chronic respiratory complaints and that the antra could be easily punctured while under the anesthetic. Only children who had a chronic infection of the upper air passages were subjected to this procedure. The technique of the puncture and the bacteriological examination of the antra are described. The main fact that emerges is that out of 100 children having a tonsil and adenoid operation 24 were found to have mucus, mucopus, or pus in one or both antra. Most of these cases cleared up with antral lavage. In children the nose is small and easily blocked and adenoids are frequent. The common conditions giving rise to sinusitis are colds, influenza, and infectious diseases particularly whooping-cough. Bathing in infected water is another frequent cause. Sinusitis is more common in those climates where upper respiratory infections are prevalent, and is common in children who are in chronic ill health. X ray examination is a valuable aid in diagnosis, and cases can be followed up by repeated examinations of this nature. A complete cure can be anticipated in most cases in several months.

SKIN DISEASES

Investigations as to the Significance of the Sulphydrate Group for the Biologic Effects of Light P Wels and M Jokisch Strahlentherapie 1937 58, 1

The authors undertook some extensive experiments in order to discover a relationship between the biologic

effects of light and chemical reactions. If an albumin solution is exposed to a quartz mercury vapor lamp under oxygen deficiency it requires very marked reducing properties. This was shown in pigments of plants, iron, sulphur, dopa reaction, and the oxydation of adrenalin. This reducing property is lost if oxygen is added to the irradiated solution or if the irradiation takes place in the presence of oxygen. The reducing agent cannot be separated from the albumin by ultra filtration but by heat coagulation. The germinal layer of irradiated pig skin reduced more than unexposed skin when testing it with the Unna stain. The authors conclude that the photochemical production of reducing sulphydrate groups in irradiated skin is of importance for light biological effects. Although their experiments were carried out with solutions and on dead skin, similar processes probably take place in living skin during irradiation.

ERNST A POHLE, M D, Ph D

THE SKULL

Disease Pictures with Changes of the Inner Table of the Skull Nicola Pende München med Wchn schr May 28, 1937, 84, 855-858

The author proposes the name hyperostotic endocraniosis of Morgagni for the 'Stewart Morel syndrome'—frontal hyperostosis with obesity of masculine distribution. He observes that association of cranial hyperostoses is often frontal but occasionally elsewhere, sellar changes are characterized by thickening of the posterior clinoid processes or enlargement of the sella, increased digital markings, calcification of the falx, frequent intractable headache, with periodic continuous course, pathologic obesity of the hypogentil type, neuroses of the vegetative nervous system and evidence of endocrine injury. The syndrome may resemble a number of other diseases when not typical. The changes in the base have been observed in an increasing number of cases, accompanying the frontal hyperostoses. They suggest to the author either a chronic atrophic inflammation of the hypophysis or a tumor or hypertrophy, corresponding to which signs of hypophyseal insufficiency or over function may be observed. The process is considered primary in the hypophyseal and tuber regions, exercising a secondary influence on the skull envelope. The Italian school considers it definitely inflammatory and infectious and possibly related to sinus disease.

Accepting the view of inflammatory origin, cure will depend on the difficulty of influencing a chronic hyperplastic osteitis, and of discovering the pathogenic factor in each case. Roentgen therapy with small doses or short wave diathermy and very small doses to the frontal and hypophyseal regions accompanied with injections of parathyroid extract, thyroxin and posterior pituitary extract were tried. Results are not available.

The question of the identity of the author's cases, those hitherto described under the name Stewart Morel syndrome and the first case of Morgagni is discussed.

His illustrations show in toxic cases of the disease, diffuse osteitis of other portions of the skull as well. Henschen describes changes which are similar, occurring in 40 per cent of women during the menopause. The author feels that further study of this question is needed.

LEWIS G. JACOBS, M D

THE SPINAL CORD

Rational Roentgen Therapy of Acute Non suppurative Inflammation of the Spinal Cord. P. Del Buono. *Strahlentherapie*, 1937, 58, 251.

Roentgen therapy offers the best results in the treatment of poliomyelitis in children. Less benefit may be expected in the same disease in adults, in multiple sclerosis, both the acute and chronic type. An analysis of the literature shows that the technic of irradiation, the quality and quantity of the rays used, has no fundamental effect on the end-result since successful treatment has been reported by various authors using entirely different techniques. The author could not find any reports regarding radiation injuries of the spinal cord even following the application of large doses in young individuals.

ERNST A. POHLE, M D, Ph D

THE STOMACH

Hernia of the Cardia of the Stomach. M. Jerz. *Glass Arch d mal de l'app digestif*, 1937, 27, 266-271.

The author describes the clinical and roentgenologic findings of a case of esophageal hiatus hernia in which he believes the condition is due to rachitic and emphysematous deformity of the thorax, causing distention of the esophageal hiatus and relaxation of the cardiac sphincters.

S. RICHARD BEATTY, M D

Gastric Lesions Simulating Cancer. R. Savignac. *Arch d mal de l'app digestif*, March, 1937, 27, 233-247.

In a discussion of the differential diagnosis between gastric ulcer and carcinoma the author presents three cases in which the roentgenologic studies indicated the presence of cancer, but in which the correct diagnoses were respectively, alcoholic gastritis, old gastric ulcer with adhesions to the anterior abdominal wall, and a prepyloric ulcer. In each case, despite the roentgenologic findings the clinical course did not confirm the impression of malignancy.

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Experimental Observations in Gastric Ptosis. L. Gleize Rambal. *Bull et Mém Soc Radiol Méd de France*, January, 1937, 25, 66-70.

Consideration of the anatomy of the stomach and duodenum makes it evident that there is but one point of fixation or suspension for the stomach, this is at the cardia, where the stomach is supported by the esophagus, and by direct attachment of the fundus to the diaphragm.

The stomach rests on the mesocolon as on a shelf. When the colon is filled it rises in the abdomen due to the fact that the mesocolon and the small intestinal coils prevent motion in any other direction. This has been observed by roentgenologic study of the barium- or air filled colon, with the patient upright.

Consequently, gastroptosis is, in the vast majority of cases, determined by coloptosis, and gastropexy is, for this reason, an illogical procedure.

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THE THYROID

Experimental Hyperthyroidism and its Treatment by Roentgen Rays. A. Jugenburg and B. Schlepakow. *Strahlentherapie*, 1937, 59, 60.

The authors undertook an investigation to determine the mechanism of the therapeutic effect of roentgen rays in Basedow's disease. Dogs were given thyroekrin (by mouth) in order to produce the symptoms of hyperthyroidism. The animals that received treatment were irradiated according to the following technic: 180 kv, 0.5 mm Zn + 3 mm Al, 23 cm FSD, 6 x 8 sq cm field, 360 r given three times at intervals of from six to seven days. A total of 10 dogs were used in the study. Careful observations were made of the behavior of the animals, their appetite, function of the gastro-intestinal tract, pulse, weight, iodine content of the blood, and basal metabolic rate. Further studies included the so-called Reid Hunt reaction on mice and the effect of the blood of the dogs on the metamorphosis of larvae of frogs. Under the influence of the drugs the dogs developed typical thyrotoxic symptoms in the course of three months. The first effect of radiation was seen in a drop of the basal metabolic rate, an increase in the body weight, and a return of the iodine content of the blood to normal values. After a period

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of from four to five months the dogs were killed by means of chloroform and the thyroids studied histologically. A comparison of the control animals, the unirradiated and irradiated thyrotoxic dogs, showed that the glands of the control animals were the smallest, the irradiated animals had glands of about the same size as the untreated controls, and the unirradiated hyperthyrotoxic animals had the largest and heaviest thyroids. The histologic examination corresponded to the macroscopic appearance, the thyrotoxic unirradiated dogs had thyroids showing the typical picture of Basedow's struma.

After an analysis of their findings the authors conclude that the beneficial effect of roentgen rays in thyrotoxicosis cannot be due to a direct effect on the thyroid tissue but must be explained by an action on the vegetative nervous system.

ERNST A. POHLE, M.D., Ph.D.

TUBERCULOSIS, PULMONARY

Intrapleural Pneumolysis in Closing Tuberculous Cavitation. George L. Stivers. Jour Am Med Assn, Jan 10, 1937, 108, 170-179.

The closure of a tuberculous cavitation by the elimination of pleuropulmonary adhesions necessitates a complete study of the intrathoracic cavity by intrapleural thorascopy. Thorascopy visualizes the contents of the pneumothorax cavity in the living subject and defines the anatomy of the lung and chest wall with a richness of true color that is distinctive.

The average results of compression in 100 cases of artificial pneumothorax in which some degree of collapse was obtained are considered. A complete collapse was established in approximately ten of these 100 cases. A selective collapse of the diseased area giving satisfactory results was attained in another ten cases. As a result of pleural adhesions that united the lung and chest wall 80 cases remained in which lung collapse was ineffectual. Of these 80 cases, 20 were classified as a group in which by continuous cautious pneumothorax therapy, a satisfactory partial collapse was brought about. Another 20 cases showed by roentgenologic examination that the pathologic process was so far advanced or so complicated that therapeutic pneumothorax was given only to prolong life.

Forty cases remained in which pleuropulmonary adhesions constituted mechanical obstructions that prohibited, even with the most careful pneumothorax technique, a satisfactory closure of cavitation. These patients were referred to the thoracic surgeon as possible subjects for intrapleural pneumolysis. About 15 of these cases were deducted for various prohibitive reasons. Among these were the presence of large fan-shaped large round or interlocking adhesions shown on the x-ray films cavity prolongation into the adhesion, some purulent exudate, extensive contralateral pulmonary disease, very flexible mediastinum, or some other serious complication rendering them unsuitable for intrapleural pneumolysis. There were other cases found inoperable at the time of operation after the

thoroscope had been introduced into the chest cavity (13 per cent of those accepted for operation), due to the presence of blood vessels, lung tissue, or caseous material in the adhesions.

Only 22 patients of the original 100 taking pneumothorax appeared to be appropriate subjects for intrapleural pneumolysis.

CHARLES G. SUTHERLAND, M.B. (Tor.)

TUMORS (DIAGNOSIS)

Pre-operative Diagnosis in Malignant Tumors. R. Huguenin. Le Cancer 1935 12, 203-212.

The variety of modifications in neoplastic lesions and alterations in neighboring tissues produced by their presence make available methods of diagnosis not excluding the histologic techniques uncertain. A single fragment of tissue removed at biopsy, may include only benign or inflammatory tissue adjacent to the actual malignancy and lead to an erroneous diagnosis.

It is imperative that several fragments from different parts of a suspected region be examined. During thyroidectomy or mastectomy for instance, repeated examinations from several fields furnish the only complete diagnosis of the lesion, its extent and variety. Following this plan one obtains information valuable, not only in guiding the extent of the operation, but in planning future therapy.

Transillumination of the breast preceding operation will allow one to mark down the zones from which fragments are to be removed for study as opacities of varying degrees are noted.

S. RICHARD BEATTY, M.D.

The Pre-operative Visualization of Breast Tumors. N. Frederick Hicken, R. Russell Best, Charles F. Moon, and T. Tennyson Harris. Jour Am Med Assn March 13 1937 108, 864-867.

Tumors of the breast can be visualized *in situ* by contrast roentgenographic studies. The neoplasms are rendered visible by outlining them with such contrast media as stabilized thorium dioxide sol, lipiodine and air. This can be accomplished in one of two ways. The first method consists of injecting the milk ducts with the radiopaque substance and then making stereoscopic roentgenograms, which on study reveal an accurate anatomic pattern of the injected ductal system. Similar visualization studies can be made by inflating the breast tissues with air.

Mammograms not only locate the offending tumors but also determine the degree of involvement.

Aeromammograms (insufflations of air) are valuable in facilitating the diagnosis of breast tumors, particularly lipomas, fibroadenomas, simple retention cysts and carcinomas. They have, however, definite limitations: they do not visualize small papillomas, early carcinomas, small retention cysts or cystic dilatation of the milk ducts.

The combination of ductal injection and the insufflation of air is ideal, for it permits a complete visualization of all the structures of the breast

CHARLES G SUTHERLAND, M B (Tor)

TUMORS (THERAPY)

The Effect of Roentgen Therapy Applied to Normal Skin Areas on Tuberculous Lymphoma H Quastler *Strahlentherapie*, 1937, 58, 688

The author has tried a method of treatment in patients with tuberculous glands consisting of the exposure of some normal skin areas on the abdomen or back in addition to local treatment over the involved glands. The 'auxiliary radiation,' as he calls it, consists of the exposure of 20×20 cm sq fields anteriorly and posteriorly twice on four successive days with 70 kv, 0.25 mm Al, 40 cm FSD, 10 r/min, 200 r per field and sitting. From two to four days later the involved glands are exposed with the same technic and given about 75-100 r effective in the diseased tissue. According to his experience, the response to this treatment is better than with local treatment alone, and although he cannot explain the mechanism of this effect, he believes that the procedure will improve our results.

ERNST A. POHLE, M D, Ph D

Treatment of Malignancy L Schönbauer *Med Klinik*, Feb 5, 1937, 33, 185-188 (Reprinted by permission from *British Med. Jour.*, April 10, 1937, p 58 of *Epitome of Current Medical Literature*)

The author evaluates modern methods of treatment of malignant tumors with surgery, x-rays, and radium by analyzing in the literature the percentage of successful results achieved in tumors of various parts of the body. He points out that radiological treatment is of value only in malignant tumors of which the parent tissue is radiosensitive. In this category belong the seminomas, folliculomas, lymphosarcomas, epitheliomas, and carcinomas. All others are radio-insensitive unless they are anaplastic—that is, completely differentiated from their parent tissue or through metaplasia converted into radiosensitive tumors. Surgical methods alone achieve success in the treatment of tumors of the brain (20 per cent), gastro-intestinal tract (30 per cent in radical removal), kidneys (25 per cent), bladder (30 per cent), and corpus uteri (60 per cent). X-ray and radium treatment is of more value than operation in tumors of the tonsils, thyroid, penis, testicle, and bones of the extremities. Tumors of the skin are successfully treated in 95 per cent of cases by any method. Cancer of the breast can be cured in 100 per cent of early cases by operation, but in its later stages irradiation in addition to surgery greatly improves the results. Combined surgical and radiological methods better the results by 15 per cent in tumors of the lips (72 per cent successes by operation alone), by 50 per cent in those of the tongue (15 per cent) and in those of the larynx and cervix uteri. Tumors of the esophagus, gall bladder,

liver, pancreas, lung, and prostate are at present outside the category of successful results by any method, but the author is encouraged by the rapid strides made in radiological therapy to think that these and other inoperable tumors will eventually be successfully treated.

Roentgen Therapy of Mediastinal Tumors, with Report of Case of Lymphocytoma M Joly *Paris Méd.*, Feb 6, 1937, 1, 131-136 (Reprinted by permission from *British Med Jour.*, May 8, 1937, p 75 of *Epitome of Current Medical Literature*)

The author discusses the different types of mediastinal tumors and their treatment by x-rays. The most common mediastinal tumors are lymphosarcomas. They grow rapidly and soon invade the lungs, and they may also invade the pleura and pericardium. They may cause compression of the aorta, the large veins, or of the recurrent laryngeal, vagus, or phrenic nerves. These tumors are very radiosensitive. The author advises four fields for irradiation, namely, an anterior, two lateral, and a posterior field. He recommends the use of a deep therapy of 180 to 200 kilovolts, filtered through 0.5 mm of copper with 1 mm of aluminum, and large fields of about 15 by 15 cm. Wherever possible the first treatment should aim at the administration of 750 r to the tumor itself at the first sittings. This, however, may give rise to a severe reaction. In cases with considerable dyspnea it is therefore preferable to start the treatment with 625 r applied to the anterior field. If no severe reaction follows, further doses of 625 r may be given daily to successive fields until each field has had a total of 3,500 r. In resistant cases the filtration may be increased to 1 mm of copper and the total dose for each field to 4,500 r. Diuretics, laxatives, and daily warm baths are useful during the course of treatment.

A Case of Malignant Intracranial Tumor Reduced by Roentgen Therapy A Lambadaridis *Strahlentherapie*, 1937, 59, 175

The author saw a patient with a tumor in the parietal bone which he diagnosed from the roentgenogram as "giant-cell or malignant sarcoma." He gave the patient two series of roentgen-ray treatments: one in June and July (16 sittings of 45 minutes each), the second series in October (20 sittings of 60 minutes each), and applied a total dose of 8,600 r at the rate of 4 r/min. The tumor responded promptly to the treatment and after three years the patient was still free from recurrence.

ERNST A. POHLE, M D, Ph D

THE UTERUS

Serious Complications Encountered during Treatment of Carcinoma of the Uterine Cervix. Harry H. Bowing and Robert E. Fricke *Am Jour Roentgenol and Rad Ther.*, October, 1936, 36, 490-497

Of 541 patients referred for radiation therapy of carcinoma of the uterine cervix in the years 1930-1934, 91 per cent (495 patients) were accepted for treatment.

The number and severity of complications following radiation therapy of cervical cancer depend largely upon the extent of the malignancy and upon the patient's general health. Unfortunately the vast majority of the cases treated were in the inoperable (Stages III and IV) group. When the growth is too extensive for possible cure or when distinct metastases are demonstrated or when the patient's general health is impaired, limited treatment only is planned. In such cases only about one third or one fourth of the dosage used in complete treatment is administered. In spite of careful individual planning of the radiation dosage, 56 per cent of 495 cases treated, developed major complications, with death ensuing in 12 per cent of the cases. These complications are not to be considered the result of the treatment so much as the result of the acute inflammatory processes and infections which accompany malignancy. By dividing the radium doses, many of the common major complications such as pelvic cellulitis and hydronephrosis may be forestalled.

J E HABBE, M D

Clinical Results and Histologic Changes Following the Radiation Treatment of Cancer of the Corpus Uteri. A N Arneson. *Am Jour Roentgenol and Rad Ther* October, 1936 36, 461-475.

Pre-operative roentgen treatment of corpus cancer appears to definitely enhance the results of surgery whereas post-operative treatment only appears less valuable. The combined use of radium and the x ray, given before operation, probably accounts for the improved end results. Hysterectomy alone produced better results in the author's cases than irradiation alone in the technically operable cases although in patients with Grade III tumors, irradiation alone (radium plus x rays) gave better results than operation only.

If operation is decided against a course of external irradiation by divided dose technique should be administered first, to be followed by the insertion of radium. A full course of x rays requires about 1500 r to each of six fields and 3,500-4,000 mg-hr of radium is the required dose of radium for a uterus of average length.

If hysterectomy is to be performed, pre-operative irradiation is advocated in every instance, but the technique is changed to single exposures to each pelvic field, following which radium is also used routinely.

Age, plus complicating additional conditions may make a technically operable case seem better treated by irradiation only.

From histologic studies carried out following irradiation the writer concludes that from five to ten threshold erythema doses must be delivered to every part of the tumor to produce permanent sterilization of all tumor cells.

J E HABBE, M D

VON RECKLINGHAUSEN'S DISEASE

Study of von Recklinghausen's Disease. Y Hiraga. *Jap Jour Dermat and Urol*, Jan 20, 1937, 41, 1-6 (Reprinted by permission from *British Med Jour*, May 15 1937, p 77 of *Epitome of Current Medical Literature*).

The author describes his findings in 12 cases of von Recklinghausen's disease. Only one case showed the cardinal symptoms of skin and nerve tumors and large and small pigmented patches. One case occurred in a girl of 13. In two cases there were anomalies of hair and bone, and in eight the condition was found in other members of the family. In eight cases the skin was thickened and abnormally elastic in those parts affected by pigmentation and tumor formation. The most common changes in the cerebrospinal fluid were an abnormal globulin reaction, protein increase, and usually lymphocytosis. The fluid pressure was almost always raised. In four cases Hiraga obtained an encephalogram, one of which was normal, but in the remainder there was evidence of enlargement of the ventricles and the subarachnoid space. Nine cases in which the ear was examined all showed some abnormality. In six cases in which the vegetative nervous system was examined no etiological relation between it and the disease could be demonstrated. Hiraga found sudanophil cells which are the phagocytes derived from the tumor cells in eight cases. He irradiated the spine in two cases with the hope of affecting the skin tumors, but without any beneficial result. Hiraga believes von Recklinghausen's disease to be an hereditary anomaly in the same sense as a nevus.

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TRAUMATIC RETROPERITONEAL RUPTURE OF THE DUODENUM

DESCRIPTION OF A VALUABLE ROENTGEN OBSERVATION IN ITS RECOGNITION

By LOUIS SPERLING, M D, and LEO G. RIGLER, M D, *Minneapolis, Minn*

From the Departments of Surgery and Radiology of the University of Minnesota

THE duodenum, being protected by the liver, colon, transverse mesocolon, the mesenteric root, and the lower thorax, is but rarely ruptured by blunt traumatism of the abdominal wall. However, when the trauma is severe, the fact that the duodenum is fixed to the rigid spinal column favors its rupture. Only the uppermost first portion of the duodenum possesses a complete peritoneal covering. The second and third portions are covered by peritoneum on their anterior aspect only. Hence the anatomic classification of retroperitoneal and intraperitoneal duodenal rupture.

In 1895 Petry estimated the number of traumatic duodenal ruptures at 5 per cent of the injuries of the gastro-intestinal canal. In 1907 Hertle estimated its occurrence at about 10 per cent. Counsellor, at a more recent date, also stated that the duodenum is involved in about 10 per cent of all cases of traumatic rupture of the bowel. In 1922 Furtwaengler gathered 118 cases. The incidence of duodenal rupture no doubt has increased tremendously with the increasing incidence of automobile accidents.

The prognosis is, generally speaking, bad. Furtwaengler observed 14 recoveries in 118 cases (11 per cent). Schumacher, in 1910, estimated the mortality to be 90 per cent. Berry and Giuseppi (1908) reported a mor-

talidity of 87.2 per cent in a series of 132 cases of traumatic perforation of the intestine. Of 23 cases of duodenal rupture reported by them, three were retroperitoneal. Schumacher collected 91 cases of subcutaneous rupture of the duodenum, 23 of them retroperitoneal. In 14 of 29 cases collected by Soderlund the site of the perforation was not discovered at the time of the operation. In 15 of the cases reported by Berry and Giuseppi the site of rupture was not found at operation.

Because this serious complication may be overlooked even at operation, emphasis must be laid on any helpful symptom or sign which might give a clue to the correct diagnosis. Harris has emphasized that in retroperitoneal rupture of the duodenum, crepitation of the retroperitoneal tissues is found. Butler and Carlson report a case in which gas could be palpated in the pelvic tissues on rectal examination. They add that, on making an abdominal incision, when gas or air is found between the peritoneum and the transversalis fascia in a patient who has suffered abdominal injury, retroperitoneal rupture of a hollow viscus should be suspected. They also call attention to severe testicular pain which may occur, thus they attribute to irritation of the testicular nerves by bile and duodenal juices in the retroperitoneal space.

So far as we can determine, there have

been no case reports in the literature in which the diagnosis was made largely by roentgen examination. In recent years between the liver and the lateral abdominal wall. Furthermore, an antero-posterior film of the abdomen with the patient supine



Fig 1. Roentgenogram of abdomen 24 hours after injury. Gas collected about right kidney, right psoas muscle and retrocecal region is shown (arrows). Note bubble like character of shadows characteristic of emphysema of tissues rather than free gas.

roentgen examination of the abdomen in all patients suspected of having a perforation of a hollow viscus has been generally adopted. In this clinic films made with the patient upright are usually obtained to demonstrate free gas in the peritoneal cavity; the gas should extend beneath the diaphragms and be delineated in this position. In addition, postero-anterior roentgenograms with the patient lying on the left side are made to demonstrate, if possible, gas

is obtained to determine the presence of gas in the intestine and its distribution.

We wish to report a case of retroperitoneal rupture of the duodenum in which, because of the routine procedure outlined above, the diagnosis was made by the roentgen observation of gas about the right kidney. Recovery occurred under a régime of conservative therapy without operation.

Case 1. R. R., a boy, aged 19, was admitted to the hospital on May 18, 1934,

with the history of having been kicked in the mid-epigastrium by a horse 20 hours before admission. He had been thrown to the ground and was unable to stand. The patient suffered sudden excruciating abdominal pain which became progressively worse. He vomited several times. There was severe hematemesis on the morning of admission. Dysuria but no hematuria was present.

On examination 20 hours after injury the patient was not in shock. The blood pressure was 124/80 mm Hg, temperature 100.4 degrees, pulse 100 and of good quality. The head and neck were essentially negative, and the chest was clear. There was marked tenderness and rigidity of the upper abdomen, more marked on the right. Rebound tenderness was present. There was tenderness in the right lumbar region. On rectal examination there was tenderness high on the right.

Laboratory Findings—Hemoglobin, 100 per cent, leukocytes, 14,900, neutrophils, 89 per cent. Blood, Group 2. Urine, numerous white blood cells in sediment.

Roentgenograms of the abdomen, made with the patient in the erect posture, did not reveal the presence of gas under the diaphragm. There was some separation of the liver edge from the lateral abdominal wall. This was attributed to the presence of intraperitoneal hemorrhage, most likely from the liver. A large amount of gas was seen accumulated about the right kidney and this was interpreted as representing an emphysema of the retroperitoneal tissue (Fig 1). This was in the form of bubbles and striations as would be expected with air in the tissue, but not free in any cavity. The gas did not change in position with shifting of the patient. A diagnosis of retroperitoneal rupture of the duodenum was made. Because of the long history (20 hours) and because rupture of an intraperitoneal hollow viscus could be ruled out (no free gas in the peritoneal cavity), conservative therapy was instituted. There appeared to be no increase in the gas outside the bowel as indicated by another postero-anterior scout film of the abdomen made

some hours after the institution of suction, which finding seemed to justify continuance of conservative treatment. Heat was ap-



Fig 2 Roentgenogram of stomach and duodenum with barium meal five months after recovery showing deformity of second portion of duodenum (arrow) incident to healing of rupture.

plied to the abdomen, and fluids were given para-orally. The patient was carefully observed for evidence of further bleeding. The general condition remained good. By the third day the temperature had risen to 103 degrees, and then gradually it subsided to normal. An adequate fluid intake—3,000 to 5,000 c c daily—was assured by intravenous and subcutaneous administration of 5 per cent glucose in normal saline solution. Duodenal suction siphonage was instituted with nasal tube, and the fluid drainage was restored to the patient by proctoclysis.

Duodenal suction siphonage was discontinued on the tenth day after admission. The patient was gradually put on a full diet. He was up and about on the twelfth day, and was discharged 13 days after admission. Roentgen examinations three days and six days after admission showed a diminution of the amount of air surrounding the kidney. An examination three weeks following the injury revealed only a very small amount of gas present about the

lower pole of the right kidney. The kidney outline was normal. Later, roentgen examination of the stomach and duodenum with the barium meal revealed a marked irregularity of the second portion of the duodenum, due, no doubt, to the scar from the perforation (Fig. 2).

COMMENT

The presence of gas in the retroperitoneal tissues could occur in only three ways: by artificial introduction, by an infection with a gas-forming organism, and by rupture of a hollow viscus which has a retroperitoneal course. It was obviously unnecessary to consider the first possibility. The absence of an external wound made the second possibility extremely improbable. The clear history of trauma, the symptomatology which suggested a ruptured viscus, the absence of free gas in the peritoneal cavity as shown by roentgen examination all pointed clearly to rupture of a viscus into the retroperitoneal tissues about the kidney. The presence of the gas on the right side only, in exactly the position in which the second portion of the duodenum extends retroperitoneally, strongly suggests a rupture of this segment of the bowel. That a retroperitoneal portion of the ascending colon may have been the source of the gas escape cannot be positively excluded, but yet remains unlikely in view of the subsequent finding of the deformity in the duodenum. The location of the initial injury is also much in favor of duodenal rupture. The gradual absorption

of the gas and the characteristic deformity of the duodenum, observed later on roentgen examination, clearly confirm the original diagnosis. This case demonstrates a roentgen sign of perforation of the duodenum which may be of great value in the early diagnosis of this condition.

SUMMARY

A case of retroperitoneal rupture of the duodenum diagnosed by roentgen examination, with spontaneous recovery, is reported.

Attention is directed to the value of the roentgen finding, of emphysema of the perirenal tissues, as a helpful diagnostic sign of retroperitoneal rupture of a hollow viscus.

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PRIMARY APICAL LUNG CANCER PRODUCING THE SYMPTOMATOLOGY OF A SUPERIOR PULMONARY SULCUS TUMOR

REPORT OF A CASE

By HAROLD W JACOX, M D, and MARGARET R BAKER, M D, *Pittsburgh*

From the Department of Radiation Therapy and the Institute of Pathology
of the Western Pennsylvania Hospital

MALIGNANT tumors of the pulmonary apex and thoracic inlet have been studied intensively within the last five years. Opportunity to examine autopsy material from a case with the symptomatology, clinical and roentgenographic findings of superior pulmonary sulcus tumor confirms the belief that this tumor arose from the mucosa of the terminal bronchioles in the apex of the lung. The clinical features of this condition are entirely different from those of carcinoma arising in a large bronchus of the upper lobe, probably because of location and mode of spread.

CASE REPORT

A steel worker, 46 years of age, white, was admitted to the Western Pennsylvania Hospital, March 8, 1937, complaining of cough, hemoptysis, and pain in the right upper chest and arm. His health had been good until six years previously, at which time he suffered a "nervous breakdown." While working in a mill he fainted and was carried home, where he remained for six weeks. He was told he had low blood pressure but was permitted to return to work and was in good health until September, 1936.

In September he began to cough frequently and raise bloody sputum. Shortly afterward he developed pain in the right clavicular region which radiated down the arm to the elbow. These symptoms became progressively worse, the cough had been especially severe the last two weeks before admission, and the pain had radiated down to the hand since January, 1937. This pain was so severe that it interfered with his sleep, made it difficult for him to use his right hand, and was not relieved by narcotics. He had lost some weight, but

complained of no dyspnea. He was referred from a tuberculosis sanatorium where he had remained three weeks.

The past and family histories were irrelevant.

Upon examination the patient appeared emaciated, cachectic, and very weak. Horner's syndrome was present on the right presenting a ptosis of the lid and contraction of the pupil. The right eye reacted sluggishly to light, the left appeared normal. The anterior cervical lymph nodes were palpable bilaterally. There was fullness and tenderness of the right supra- and infraclavicular fossæ, with a hard, fixed mass. The superficial veins of the right upper chest and neck were dilated. The upper right chest showed diminished excursion and dullness to the level of the third rib anteriorly. Breath sounds were absent in the apex, and there was bronchial breathing in the first and second interspaces anteriorly. No râles were heard, and the rest of the right lung appeared hyper-resonant with exaggerated breath sounds. The left lung seemed normal. Definite clubbing of the fingers was noted, and there were palpable lymph glands in the right axilla. There was muscular wasting of the arms and forearms, worse on the right. The systolic blood pressure was 98, the diastolic 66. No sputum could be obtained for examination. Urinalysis showed a 1 plus albumen, 12 to 15 white blood cells per high power field, and occasional granular casts. The hemoglobin was 80 per cent, the red blood cell count was 4,000,000, and the white blood cell count was 22,000 per cubic millimeter. The differential count was polynuclear cells 83 per cent, small lymphocytes 9 per cent, large lymphocytes



Fig 1-A

Fig 1-A Chest, bedside examination showing advanced lesion in the right apex. Note infiltration and cavitation at lower border of mass.



Fig 1-B

Fig 1-B Shoulder demonstrating density in apex and neck with destruction of the right first two ribs and vertebrae.

9 per cent, transitional cells 5 per cent, myelocytes 2 per cent. Blood chemistry showed a non-protein nitrogen of 53 mgm per 100 c c (normal value 26-40), creatinine and sugar within normal limits. The blood Kahn reaction was negative.

X-ray examination of the chest upon admission revealed a soft tissue tumor and cavitation in the right upper lobe, with destruction of the posterior portion of the first and second ribs and some erosion of the transverse processes of the right vertebral border. There was no involvement of the scapula or clavicle. A diagnosis of superior pulmonary sulcus tumor was made (Fig 1).

The Tumor Clinic recommended surgical measures for the relief of pain, since radiation therapy probably would not control the symptoms. Consequently, a high left cervical (third) chordotomy and right

fifth, sixth, and seventh cervical rhizotomies were performed. At operation there was a thin layer of grayish, lobulated soft tissue which appeared to be tumor tissue, outside the dura at the lower end of the wound. During the post-operative course the patient suffered considerable pain and grew steadily weaker. He died one month after admission, or seven months after the onset of the disease. Necropsy was performed six hours after death.

Necropsy (A-99) Gross Anatomy—The body was that of a well developed, emaciated, white male 46 years of age, 179 cm long. There was a marked fullness of the neck above the lateral half of the right clavicle and a firm, nodular mass about 4 cm in diameter could be palpated in this position. It seemed to arise from beneath the clavicle as the lower margin could not be identified. The chest and abdomen

showed no abnormalities. There were decubitus ulcers posteriorly over the right shoulder and buttock.

The upper lobe of the right lung appeared greatly enlarged, occupying nearly two-thirds of the right chest cavity. This increase in size was due to a globular mass 10 cm in diameter situated in the apex and smoothly continuous with the rest of the upper lobe. The entire external surface of the lung, including the apical enlargement, was smooth and grayish-black. The lower lobe was bound to the chest wall laterally and posteriorly by fibrous adhesions, while the mass in the upper lobe was so tightly adherent over its entire posterior surface that it could be removed only by sharp dissection (Fig 2).

The upper lobe, exclusive of the globular enlargement, was almost normal in size, measuring $5 \times 13 \times 16$ cm. Crepitanity was elicited throughout the upper lobe except in the region of the mass, which was exceedingly firm and tense. The cut surface of the latter revealed a rounded, sharply defined, non-encapsulated mass of soft, exceedingly friable, slightly granular tissue which varied in color from white to yellowish-white. The pure white areas were of an almost homogeneous smoothness, while the yellowish-white portions were usually finely granular. A few very soft, degenerated, brownish-pink areas were also present.

Anteriorly and on both sides this mass was surrounded by a paper-thin envelope of lung tissue. Posteriorly, it was adherent to the ribs and had invaded and destroyed the first three ribs for a distance of two or three centimeters from the vertebral border laterward and had also produced slight roughening of the sides of the corresponding vertebrae. Superiorly, it was continuous with the nodular mass palpable above the clavicle. (The latter was not removed due to restrictions in the autopsy permission.) Inferiorly, the edge of the white tissue was rounded and sharply delimited from the adjoining lung. A medium sized bronchus entered the mass through the inferior border, but ended blindly almost immediately.



Fig 2. Right lung showing apical tumor (light colored portion). Tumor is ragged and collapsed due to difficulty of removal.

The cut surface of the rest of the upper lobe was dry and gray, that of the lower and middle lobes was reddish-gray and moist, with a few small, slightly raised yellow foci of bronchopneumonia. There was no lesion of the left lung. The other organs were normal except for an acute splenitis. No metastases were found.

Microscopic Anatomy—The mass at the right apex was composed of irregular islands of epithelial cells separated by a scanty amount of stroma. The cell masses varied greatly in size and shape, but the majority were quite large, frequently being long and winding, so that a papillary structure was simulated. In a few areas these epithelial islands were made up largely of prickly cells and usually contained an epithelial pearl in the center. In the majority of the sections, however, prickly cells and epithelial pearls were absent and the cells varied from polygonal to spindle in shape, the larger cells being found in the center of the islands.

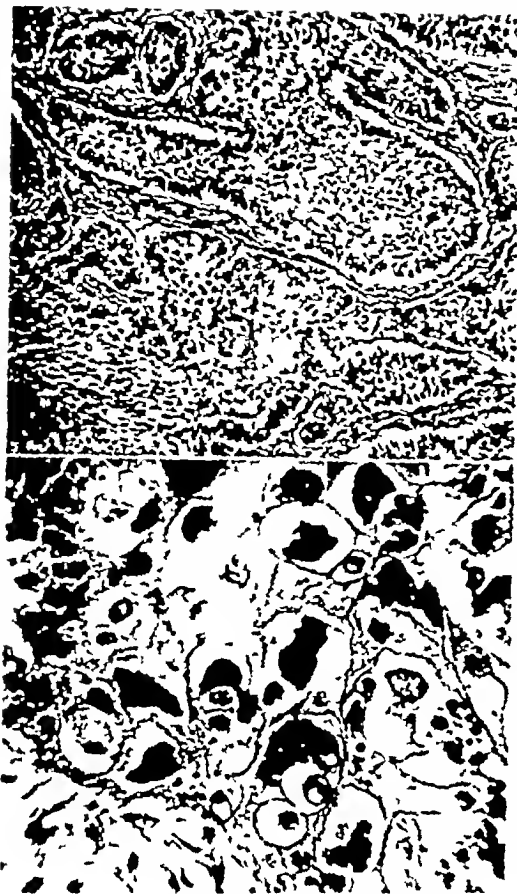


Fig 3 A (upper) Low power view of typical microscopic field ($\times 100$)

Fig 3 B (lower) High power of same ($\times 500$)
Note the marked cellular variation and giant nuclei

The individual cells varied greatly in size and shape, but were usually large with pale cytoplasm and large vesicular nuclei. The latter were frequently multilobed, the number of lobes varying from two to ten. Enormous, bizarre, hyperchromatic nuclei were very common and formed the most prominent feature of the sections. Mitotic figures were numerous in all areas (Fig 3).

Diagnosis—Squamous-cell carcinoma, originating in the apex of the right lung, and invading the ribs, vertebrae, and soft tissues of the neck.

COMMENT

The treatment of malignant tumors of the pulmonary apex and thoracic inlet is notoriously unsatisfactory. The progno-

sis is hopeless, and satisfactory palliation is difficult to obtain. The characteristic pain can be relieved sometimes by physical therapeutic measures or alcohol injection, but the relief even with intensive roentgen therapy is usually only temporary. In our patient, although the disease was so far advanced, enough relief from the terrific pain resulted to justify chordotomy and rhizotomy.

Opinion regarding the origin of these tumors varies widely. A large proportion of so-called superior pulmonary sulcus tumors appear to be lung carcinoma, often of the squamous-cell type. But in our case and in other reported cases it is difficult to explain why a tumor originating in the apex of the lung should show such extensive involvement of the ribs, vertebrae, and soft tissues of the neck, when a large portion of the upper lobe of the lung is entirely uninvolved. On the other hand, it is unlikely that a tumor originating in the neck would invade the apex of the lung so consistently.

However, this same general location could be the site of tumors arising in structures of the neck, such as sympathetic ganglia, or persistent branchial cleft tissue. Perhaps firm apical adhesions would tend to facilitate extension to the lung. The clear-cut symptomatology and clinical and roentgenographic findings of superior pulmonary sulcus tumors would, therefore, seem to be related more to the location of the tumors than to any uniform histogenesis. In this connection, however, it must be remembered that the appearance of lung carcinomas may be exceedingly diverse, and undifferentiated carcinomas may simulate other types of neoplasm.

In our case about two-thirds of the tumor was intrathoracic and definitely encapsulated by lung tissue except posteriorly. A bronchus was traced into the tumor mass. There seems to be no reasonable doubt that it arose in the lung.

SUMMARY

1. A case of primary carcinoma of the lung occurring in the apex, which supports

the view that "superior pulmonary sulcus tumors" are primary carcinomas of the lung, is described

2 Superior pulmonary sulcus tumor is not a new specific pathologic entity among intrathoracic neoplasms, but the symptoms and signs may be caused by various tumors arising near the thoracic inlet

3 Surgical measures for the relief of pain offer valuable palliation in some cases

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DEMONSTRATION OF GAMMA RADIATION FROM LIVING PATIENT FOLLOWING THOROTRAST INJECTION¹

By ROBERT B. TAFT, M.D., B.S., M.A., F.A.C.R., *Charleston, S. C.*

SINCE the introduction of thorotrast several years ago, it has been well received by the profession for the purpose of intravenous injection as a contrast medium to delineate the liver and spleen on the radiograph, but as thorium is one of the more radio-active elements, the question naturally arose as to the probability of its radiation doing damage to the reticulo-endothelial system after many years of bombardment.

I believe that I have definitely shown that the radio-activity from this preparation is well within the limits of danger.

The Geiger Counter (1) has opened great possibilities in the measurement of small quantities of radiation. Perhaps it is no exaggeration to say that it does the same thing for the radiologist that the microscope does for the biologist. Briefly, it consists of a glass tube which is partly evacuated and has a cathode charged to a

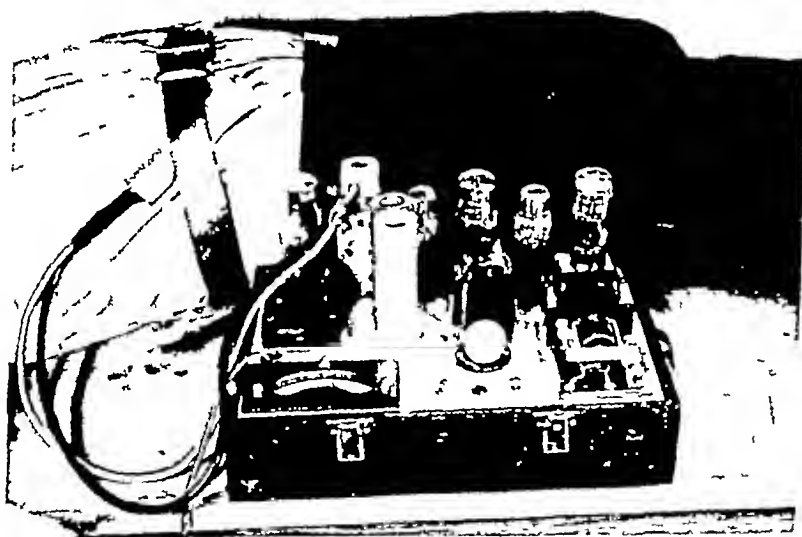


Fig. 1. The author's Geiger Counter as used in this work. The Locher tube in the metal shield can is placed on the body of the patient against the liver. Radiation causes the entrance of an occasional photo-electron into this tube. The feeble impulse is amplified by the radio tubes sufficiently to actuate the relay which in turn operates the signal light and the mechanical counter.

One writer has dismissed the matter with the statement that the radiation is negligible. Others have reached that conclusion by placing the material on a photographic film for a few hours, and, when no blackening occurred, assuming that the human body could not be damaged.

fairly high potential. The anode is connected to a system of amplifying tubes so that the feeble impulse of a photo-electron entering the tube becomes sufficiently powerful to operate a loud speaker, signal light, or mechanical counting device. The delicacy of this instrument is shown by the fact that it responds well to a 10 mg. needle of radium at a distance of more than one hundred feet. When a sealed ampule of

¹ Presented as a clinic at the Twenty second Annual Meeting of the Radiological Society of North America at Cincinnati Nov. 30-Dec. 4 1936.

thorotrast is brought near this instrument, the response is immediate and violent

Realizing that the accurate determination of the gamma-ray activity of a dose of thorotrast would be of value, I started work on the problem. A small standard of radium was obtained, not anything comparable to radium needles such as are used medically, but a crude radium salt containing three micrograms of radium element. To make this amount intelligible to the radiologist who is in the habit of dealing with milligrams, it is well to state that this standard represents an investment of about twenty-four cents. This standard was compared with the three ampules of thorotrast as follows: in a room where there was no known radioactivity and at a time when no x-ray machines were in operation, the Geiger Counter was allowed to make a base count which, of course, included cosmic radiation and any small amount of radiation which may have emanated from the soil or building. This count varies at different locations but, once established, is used as a correction factor on the instrument.

Next, the thorotrast is placed on a wooden frame along with the counting tube, the distance being an arbitrary one, but one which can be exactly duplicated. Counts are made over a long period of time so that the average per minute can be determined. After this, the radium standard is placed in the same position formerly occupied by the thorotrast and its average per minute count determined.

The base count is subtracted from the count on thorotrast and from the count on the radium, after which the counts are arranged in a proportion with the known standard in the micrograms of radium, and the unknown value in micrograms of radium equivalent of thorotrast solved.

These tests, repeated many times, showed that 75 c.c. of thorotrast gave the gamma radiation equivalent to 1.37 microgram of radium. To the radiologist who uses a hundred milligrams or more in the treatment of diseases, this small amount of radium may appear inconsequential, but

let us consider a moment. This much radio-active material is put in the human body where it remains permanently, the association not even being terminated, as are other human associations, "when death do us part." This is demonstrated by the test tube full of white powder which was once a human liver, removed at autopsy and burned down to white ashes and still showing radio-activity. Throughout the patient's life, this material would continue to radiate the body, not as a surface application of radium but from the *inside* of the cells, where not only the gamma radiation which I have demonstrated would be effective, but with alpha and beta radiation as well. Attention is called to the fact that thorium gives more alpha radiation in proportion to its gamma radiation than does radium and that the life of thorium in this form is so long that it would not appreciably diminish in an individual's lifetime.

The demonstration of radio-activity in the liver of a living patient who has previously been injected with thorotrast is a rather spectacular one. I have been able to do this with only a fair degree of accuracy because the material is so disseminated that it is impossible to use the body radiation as though it were coming from a small mass. To arrive at some kind of a standard of radiation from which to work, I made the "Phantom Liver." This is a hollow wax cast molded on a liver, cut in half and the liver removed, the cast sealed back together and then filled with 75 c.c. of thorotrast and water in sufficient quantity. This gave an object the size and shape of the liver with the 100 per cent dose. Counts were made on this and then on the body of the patient and a proportion arrived at.

The final test of the situation came when I was able to get an autopsy on a patient who died of leukemia about six weeks after having been injected with thorotrast, and on whom I had made observations during life. The liver, when burned to ash so as to get it into a small mass, showed activity equivalent to 50 per cent the original dose, and the spleen, about 12 per cent

Some small amount is lost by excretion and the remainder is assumed to be scattered throughout the body

The question which may now be logically asked is, what is the basis for assuming that so small an amount of radioactive material can be harmful? The answer is obvious to anyone who will take the trouble to review the work of Martland (2) in the studies of those unfortunate individuals who were poisoned by radium salts in the dial painting industry. In these accidents, we had a series of unintentional experiments which will certainly never be repeated, but which answered many of the questions about radium poisoning.

To summarize very briefly, *two* micrograms in the body have produced symptoms of radium poisoning, and *fourteen* micrograms have caused death.

Since this work was first presented, I have received a personal communication

from a physicist (3), stating that he has studied a body in which death was caused by 1.2 microgram.

With this knowledge on hand, does the radiologist, for diagnostic purposes, still want to inject the equivalent of 1.37 microgram radium?

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EFFECT OF X-RAYS ON THE OXYGEN CONSUMPTION OF EMBRYONIC CELLS¹

By EDGAR JOHN BOELL, PH D, MALCOM RAY, M S, and JOSEPH HALL BODINE, PH D, Iowa City

Zoological Laboratories, State University of Iowa

THAT different tissues and cells respond to irradiations in various ways seems well established (Packard, 21, Duggar, 7, and others). It is also equally well known that radiosensitivity seems in some way connected with or dependent upon the physiological activity of the cells at the time of irradiation as well as upon their subsequent history after exposure (Duggar, 7, Henshaw and Henshaw, 12, 14, Henshaw and Francis, 11, 16, 17, 18, 19, Evans, 8, 9, 10, and others). In many instances, however, conflicting data have been reported by different authors working on similar materials. The exact nature of the effects produced upon protoplasm by irradiation seems as yet obscure due perhaps to the complexity of protoplasm itself as well as to the lack of suitably controlled biological materials and methods with which to work.

The present paper is concerned with the results of experiments on the effects of x-rays on the growth, oxygen intake, oxidation enzymes, and hatching of the egg and embryo of the common grasshopper, *Melanoplus differentialis*. Of the many special advantages in the case of this biological material, perhaps none is more striking than the fact that a naturally occurring developmental block takes place in the embryo which can be more or less experimentally controlled so that all physiological conditions from a complete lack of mitosis, cessation of growth, etc., to a marked cellular activity can be easily obtained. These phenomena have been fully described elsewhere (Bodine, 1, 2, 3) and need not be enumerated again except insofar as

necessary in connection with descriptions of individual experiments. The particular problem to be considered here is the extent to which the normal oxygen uptake mechanism of the embryonic cell is influenced, if at all, as the result of x-ray irradiation.

MATERIAL AND METHODS

Methods of handling eggs and embryos were the same as previously pointed out (Bodine and Boell, 6). Oxygen determinations have been carried out in triplicate with Warburg manometers at 25° C, using some 500-600 eggs and embryos in each experiment. Inasmuch as the results of all experiments are qualitatively similar, only typical results will be presented.

The x-ray apparatus was the same as that employed in previous investigations (Evans, 10). The radiation (130 kv, 5 ma, and 35 cm distance) was applied in one treatment and the amounts were determined by varying exposure time.

I X-rays on Diapause or Blocked Eggs and Embryos—In considering the results of the effects of x-rays on the diapause or blocked embryo, it is well to keep in mind the facts that in this condition the O₂ intake is at a minimum, cell division (mitosis) is absent, growth does not occur, and that this blocked condition is a naturally occurring phenomenon, inherent in the cells of the embryo and quite independent of external temperature for its occurrence. (See Bodine and Boell, 4, for further details.)

Diapause eggs (exposed to temperature of 25° C for 56 days from time of laying) were divided into two groups. One lot served as control while the other was x-rayed with 2,040 r units (170 r per min for 12 min). Both were kept at 25° C and samples taken at intervals to determine

¹ Aided by a grant from the Committee on Radiation of the National Research Council and by the Rockefeller Foundation fund for Research on the Physiology of the Cell.

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(3) Personal communication with Robley D. Evans, Ph.D., of the Massachusetts Institute of Technology.

results of the addition of 3×10^{-5} M — D N C on the O_2 intake of control and rayed blocked embryos five days after the exposure to the x-rays

It would thus seem that the mechanisms controlling the O_2 intake of the blocked embryo as well as the mechanism stimulated by the D N C are in no way impaired by the dosage of x-ray administered. No visible morphological changes have been detected during the period of the experiment.

II *X-rays on Developing Eggs and Embryos*—Since mitosis, growth, etc., in the diapause or blocked embryo are normally inhibited by an inherent physiological mechanism which is quite independent of temperature, it was considered advisable to investigate the effects of x-rays on the growing or non-blocked embryo both in the actively growing and experimentally blocked condition. By the use of low temperature ($10^\circ C$) growth and mitosis can conveniently be brought to a standstill so that it is thus possible to determine the irradiation effects on respiration independently from those on growth and development.

In preliminary experiments the following procedures were used. Developing eggs containing embryos of stage No. 21 (Slifer, 22) were divided into two groups. One lot was kept as control group, the other x-rayed at room temperature ($25-27^\circ C$) with 2,040 r units as in the case of diapause eggs mentioned above. The eggs were

then kept at $10^\circ C$, at which temperature development is inhibited.

In some cases, as noted in Table III, embryos were dissected out and then rayed in buffered Ringer solution. The Ringer solution was of such a depth (approximately 1 mm) that the embryos were just covered by the fluid. After raying, they were washed in four changes of fresh Ringer and respiration measured over a period of from two to four hours.

In determining the respiration of the above eggs readings were always taken at $25^\circ C$. It was soon found that these exposures to $25^\circ C$ caused development to occur sufficiently to allow the control embryos to develop from the fifth post-diapause day stage to the sixth post-diapause day stage. This is evidenced by a steady increase in the respiratory rate of the controls from $41.9 \text{ mm}^3 O_2$ per 100 embryos per hour to $54.0 \text{ mm}^3 O_2$ per 100 embryos per hour. Some development likewise took place in the x-rayed eggs but at a slower rate, so that on the fifth day the controls and x-rayed individuals were no longer morphologically identical. Although, as indicated in Table III, on the fifth day the respiration of the x-rayed embryos is only 82 per cent of that of the controls, this does not indicate a deleterious effect of the x-rays on the respiratory mechanism primarily for no actual decrease in respiratory rate of the x-rayed embryos was observed. It rather suggests that development may be influenced with-

TABLE III—OXYGEN UPTAKE OF CONTROL AND DEVELOPING EMBRYOS X-RAYED WITH 2,040 r UNITS. EMBRYOS DISSECTED FROM X-RAYED EGGS INTO BUFFERED RINGER WITH EXCEPTION OF THOSE MARKED BY (*) WHICH WERE RAYED DIRECTLY WHILE SUSPENDED IN SOLUTION. EGGS KEPT AT $10^\circ C$. RESPIRATION DETERMINED OVER A THREE- TO FIVE-HOUR PERIOD AT $25^\circ C$.

Days after Raying	Control				X rayed				X rayed as Percentage of Control
	No. 1	No. 2	No. 3	Average	No. 1	No. 2	No. 3	Average	
0*	38.3	39.2	38.3	38.6	37.9	37.9	40.3	38.7	100
0*	42.7	41.4	41.5	41.9	42.5	43.9	42.0	42.8	102
3	48.7	48.2	48.2	48.4	44.3	46.2	46.8	45.8	95
5	53.0	56.0		54.0	43.7	43.5	45.0	44.1	82

their oxygen intake as well as any possible morphological changes. Respiration was determined over a three- to five-hour interval and results are expressed as $\text{mm}^3 \text{O}_2$ uptake per 100 eggs per hour. Table I gives results of a typical experiment. Upon examination of this table it will be noted

ured. From an inspection of Table II it will be evident that no significant effects of the irradiation on the contained embryos are apparent.

Not only is the normal respiration of the blocked embryo unaffected by the γ rays of the dosages used, but it can also be

TABLE I—OXYGEN UPTAKE OF CONTROL AND DIAPAUSE EGGS γ -RAYED WITH 2,040 r UNITS (170 r UNITS PER MINUTE FOR 12 MINUTES) RESPIRATION OF EGGS DETERMINED OVER THREE- TO FIVE-HOUR INTERVALS AT 25° C. THREE MANOMETERS WITH CONTROL EGGS THREE WITH γ -RAYED EGGS ALL EGGS KEPT AT 25° C

Days after Raying	(mm ³ O ₂ uptake per 100 eggs per hour)				X rayed				X rayed as Percentage of Control
	Control	Control	Control	Average	X rayed	X rayed	X rayed	Average	
1	No 1	No 2	No 3	Average	No 1	No 2	No 3	Average	
1	10.4	9.2	9.5	9.7	10.4	10.1	10.0	10.1	104
4	6.5	7.1	6.5	6.9	6.8	7.2	7.2	7.1	103
7	6.6	6.2	6.3	6.4	7.0	6.0	6.7	6.6	103
10	6.2	5.8	6.6	6.2	9.2	7.8	7.6	8.2	132
12	5.0	5.1		5.1	5.2	5.6		5.4	106

that no appreciable effects of the γ -irradiation on the O_2 intake of the diapause eggs are shown over a period of 12 days after the exposure. The blocked or diapause egg apparently is quite resistant to the action of the γ -irradiation. Such results are in agreement with those previously reported by Evans (9).

Inasmuch as it has been previously shown that effects on the intact egg are not necessarily similar to those on the contained embryo (Bodine and Boell, 5), experiments were carried out in which the embryos from irradiated diapause eggs were removed and their O_2 intake meas-

shown that the increase in respiration due to the addition of 3,5-dinitro-o-cresol to the inactive embryos is of the same magnitude as for embryos from control eggs. In Figure 1 are graphically shown the

TABLE II—OXYGEN UPTAKE OF CONTROL AND DIAPAUSE EMBRYOS γ -RAYED WITH 2,040 r UNITS EMBRYOS DISSECTED FROM γ -RAYED EGGS INTO RINGER SOLUTION PLUS M/100 PHOSPHATE BUFFER, pH 7.0 150 TO 175 EMBRYOS PER MANOMETER RESPIRATION DETERMINED OVER THREE-HOUR INTERVALS

Days after Raying	(mm ³ O ₂ uptake per 100 embryos per hour)			X-rayed			X-rayed as Percentage of Control
	Control	Control	Average	X-rayed	X-rayed	Average	
5	No 1	No 2	Average	No 1	No 2	Average	
5	6.3	6.5	6.4	6.7	7.1	6.9	108
11	5.6	5.2	5.4	5.3	5.6	5.5	102

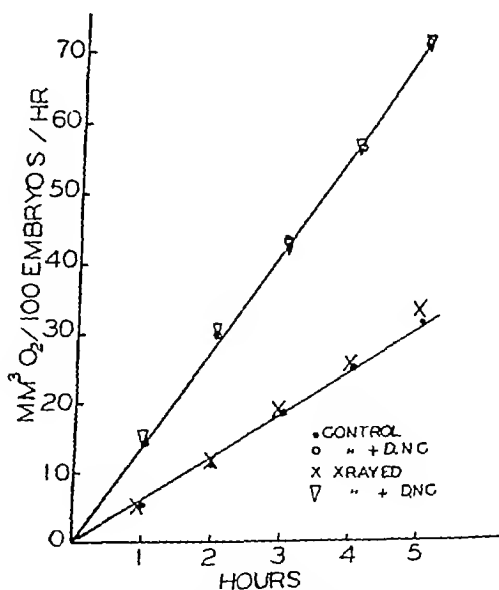


Fig 1. A graph showing the oxygen uptake of diapause embryos from eggs treated with 2,040 r units of γ -ray five days after raying also shows the effect on the oxygen consumption of adding 2×10^{-4} M 3,5-dinitro-o-cresol to the normal and γ -rayed embryos. For further description see text.

of the control. It might at first hand seem that respiration is primarily affected by the irradiation. However, when de-

son to believe that no significant differences in respiration are brought about in those eggs upon exposure to γ -irradiation

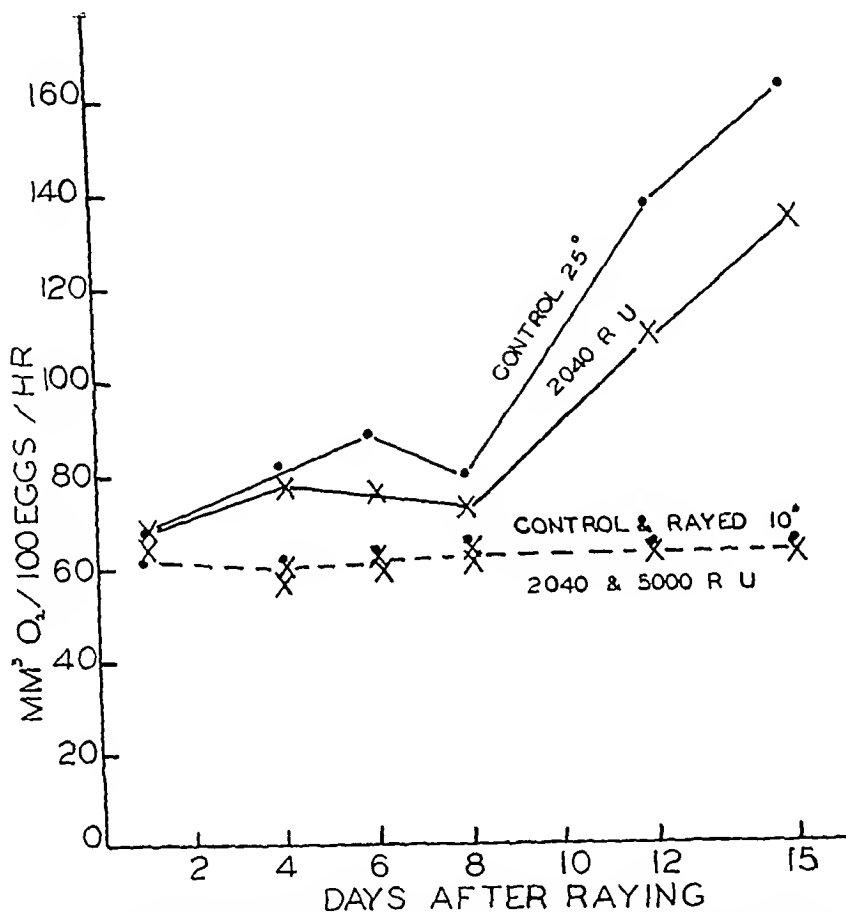


Fig 2 A graph showing the oxygen uptake of developing eggs exposed to 2,040 and 5,000 r units of γ ray and subsequently kept at 25° C and 10° C to permit of active growth on the one hand and to inhibit or check active growth on the other hand. Solid lines for actively growing embryos (25° C), broken line for inhibited ones (10° C)

velopment is inhibited at 10° C, it will be noted that no significant change in the respiration rate of control and irradiated eggs is indicated. As a matter of fact, in eggs treated with 2,040 and 5,000 r units, when development is stopped by exposure to 10° C, the average respiratory rate for the controls is 64.3 mm³ O₂ per 100 eggs per hour and for the rayed eggs it is 62.3 mm³ O₂ per 100 eggs per hour. The latter figure is 97 per cent of the control value. Since each average is made from a total of 22 individual determinations there is rea-

son to believe that no significant differences in respiration are brought about in those eggs upon exposure to γ -irradiation. From Figure 2, graphically showing results of temperature effects, it can readily be seen that when growth is inhibited no differences in the respiration rates of control and irradiated eggs are evident but that in the case of eggs allowed to develop after exposure to γ -rays, a gradual falling off in the respiration is observed. This falling off is without doubt due to a cessation or interference with growth and represents no primary effect upon the O₂ intake mechanism as such.

It is also of some interest to again note

have been pointed out in work by Evans (8, 9, 10) That the respiration mechanism is perhaps not primarily affected by irradiation seems clear from the results of the present investigation. Correlations of mitotic activity, respiration, etc., seem unlikely since in diapause or blocked embryos no mitosis occurs while respiration is at a minimum. Expressions of change in normal respiration in embryos seem only to occur in those organisms irradiated and subsequently permitted to grow. Such changes would seem to indicate fundamental ones in protoplasmic organization which are secondarily reflected in growth and respiration. Somewhat similar conclusions have been arrived at by Henshaw and Francis (16) working with plant materials.

SUMMARY AND CONCLUSIONS

1 Effects of γ -rays on the growth, respiration, and oxidation mechanism of the eggs and embryos of the grasshopper (*Melanoplus differentialis*) have been presented.

2 X-rays in the dosage supplied (2,040, 5,000 r units) do not affect the respiration (O_2 intake) of diapause or blocked embryos.

3 The stimulating action of 3,5-dinitro-o-cresol on oxygen intake of the diapause embryos is not interfered with by γ -irradiation.

4 Actively developing eggs and embryos while developing are affected by γ -rays as indicated by changes in growth and respiration.

5 X-rays applied to actively developing eggs and embryos in which growth has been stopped by exposure to $10^\circ C$ produce no measurable effect on respiration, or stimulation of respiration by the addition of 2,4-dinitro-phenol.

6 Hatching of actively developing γ -rayed eggs is greatly decreased and embryos hatching do not survive.

7 From the results of the present experiment, one is justified in concluding that γ -rays (in the dosage used) do not primarily affect the respiration mechanism of the embryonic cell but rather bring

about fundamental changes in protoplasmic organization.

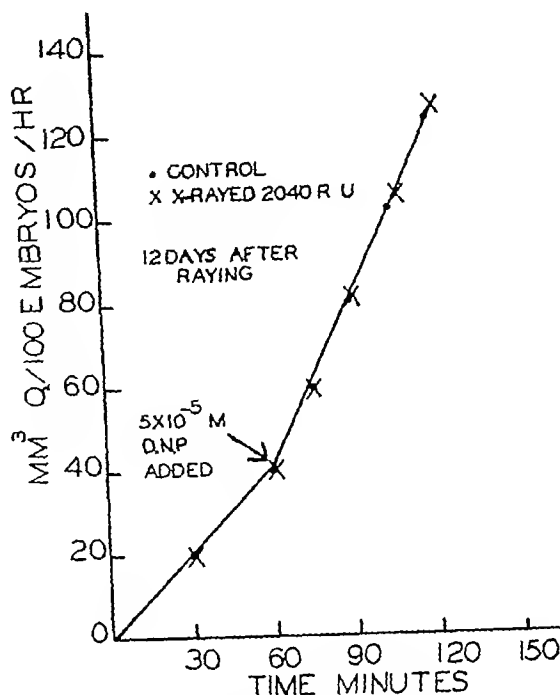


Fig 3 A graph showing the effect on the oxygen consumption of adding $5 \times 10^{-5} M$ 2,4-dinitrophenol to γ -rayed (2,040 r units) developing embryos 12 days after raying. Arrow indicates addition of reagent.

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(Table VI) that hatching of x-rayed eggs in these series is greatly reduced, and also that, even though some embryos do hatch, they invariably die immediately

TABLE VI—HATCHING DATA FROM DEVELOPING EGGS KEPT AFTER X-RAYS (2,040 r UNITS AND 5,000 r UNITS) AT 25° C AND 10° C ALL EGGS WERE TRANSFERRED TO 25° C FOR HATCHING (a) = EGGS KEPT ONLY AT 25° C AND GIVEN 2,040 r UNITS (b) 2,040 r UNITS, KEPT AT 10° C, THEN TRANSFERRED TO 25° C FOR DEVELOPMENT AND HATCHING (c) 5,000 r UNITS, KEPT AT 10° C, THEN TRANSFERRED TO 25° C FOR DEVELOPMENT AND HATCHING

		Total No of Eggs	No Hatch	No Living Nymphs	Per centage of Total Hatch- ing	Per centage of Total Living after Hatch- ing
(a)	Control	106	105	99	99	93
	X rayed	112	23	0	20	0
(b)	Control	101	96	92	95	91
	X rayed	102	9	1	9	1
(c)	Control	93	88	83	90	85
	X rayed	99	8	0	8	0

In order to check the above results on the intact egg, embryos were dissected out in buffered Ringer solution and respiration determinations made Table VII shows

TABLE VII—EFFECT OF X-RAYS (2,040 r UNITS) ON DEVELOPING EMBRYOS EGGS KEPT AT 10° C AFTER EXPOSURE TO IRRADIATION RESPIRATION OF EMBRYOS DISSECTED FROM EGGS IN BUFFER RINGER SOLUTION DETERMINED OVER A THREE- TO FIVE-HOUR INTERVAL AT 25° C

(mm³ O₂ uptake per 100 embryos per hour)

Days after Ray- ing	Control			X rayed			X rayed as Per cent- age of Con trol
	No 1	No 2	Aver- age	No 1	No 2	Aver- age	
1	37 6	38 0	37 8	48 4	49 3	48 8	129
4	44 5	43 1	43 8	40 8	37 5	39 2	90
6	38 6	39 2	38 9	36 2		36 2	93
12	37 1	39 4	38 2	35 2	40 2	37 7	99
			39 7			41 1	

data typical for embryos from eggs rayed with 2,040 r units and in which development had been inhibited by exposure to 10° C From an inspection of this table, it will be noted that no significant difference between the respiration of normal and rayed embryos is indicated As a matter of fact the average respiration of control embryos is 39.7 mm³ O₂ per 100 eggs per hour and that for rayed embryos, 41.1 mm³ O₂ per 100 eggs per hour

In addition to the absence of any effects of x-rays on respiration of eggs and embryos in cases in which development did not occur, there was likewise no effect upon the nature or rate of the contractions of the lateral body walls in rayed embryos These contractions of the lateral body wall in orthopteran embryos have been used in other experiments in this laboratory (Walker, 24, Thompson, 23) and have been found to be a delicate indication of the physiological responses of the embryos

Other evidence of the inability of x-irradiation to markedly interfere with the respiration of these embryos is given by following their response to the addition of such respiratory stimulants as 2,4-dinitrophenol In Figure 3 are graphically shown typical results of the addition of DNP to embryos 12 days after raying An inspection of this figure clearly indicates that no injurious effects on the mechanisms involved in this reaction seem to have been brought about by exposure of the embryos to x-irradiation

The many questions involved in the separation of primary and secondary effects of irradiation are undoubtedly complicated by the difficulties inherent in the limitations imposed upon the experimenter by virtue of the complexity of protoplasm itself The biological material employed in the present experiments seems more or less admirably adapted for getting some clues concerning these questions, since it is relatively simple and its normal course of development and behavior under standard conditions is fairly well known (Slifer, 22) That changes in its radiosensitivity take place during its embryonic development

CANCER OF THE THYROID

By MOSES F LUBELL, M D, Sisters Hospital, Waterville, Maine

IN this paper I wish to survey the more recent reports on diagnosis, pathologic classification, and treatment of malignancies of the thyroid gland. This subject has received intensive attention at each of the large centers for goiter treatment in this country, where a concentration of thyroid cases naturally leads to the discovery of the small percentage of malignancies among the thousands of cases operated upon.

The majority of the more recent reports on carcinoma of the thyroid sound an encouraging note in their evaluation of the results of treatment. However, as Pemberton (1) points out, "It is apparent that the fatalistic attitude is more widespread concerning this disease than concerning malignancies of other organs of equal accessibility to surgical attack."

Haagensohn (2), in his interesting paper on the radiosensitivity of thyroid tumors, makes an historical survey of methods and results of treatment, from the earlier reports based on surgery alone to the present-day combined methods of surgery and radiation which show markedly improved results.

In the study of comparative results from different centers much confusion is caused by variations in pathologic terminology so that statistical results cannot be closely compared. The peculiar pathologic picture of cancer of the thyroid resulting in histologic sections of wide variability from the same gland, ranging from apparently normal gland to definite malignancy, has resulted in confusion in nomenclature and classification. Almost all authors emphasize the difficulties in diagnosis and apparently no two agree on a standard classification.

Allen Graham (3) offers the following reasons for this unsatisfactory confusion:

(1) The failure in the past to discriminate

sufficiently between "normal" and "adenomatous" thyroid tissue.

(2) The none-too-well appreciated importance of the rôle of the pre-existing adenoma in furnishing the starting point for a very high percentage of epithelial malignancies.

(3) The great number and combinations of names, implying different pathologic entities, applied by various authors to what, in the vast majority of cases, is clearly one and the same pathologic process.

(4) The academically irreconcilable conflict between a purely morphological and a biological interpretation of the term "carcinoma."

(5) The failure to take sufficiently into account the peculiarities of the thyroid as a tissue or special organ, in arriving at what constitutes malignancy.

Incidence of Malignancies of the Thyroid—Eberts (4) found 20 cases, or 0.9 per cent of malignancy among 2,120 cases examined at the goiter clinic of the Montreal General Hospital. He found 3 per cent of malignancy in 536 cases of adenomatous goiter operated on.

From the Lahey Clinic the latest report, that of Hare (5), gives 258 cases (or 1.7 per cent) diagnosed as primary malignancy of the thyroid gland in 15,000 thyroid operations.

Pemberton reported, in 1928 (6), 323 patients with cancer of the thyroid who constituted 1.03 per cent of patients operated on for goiter.

Clute and Smith, in 1929 (7), quote a number of authorities who give an incidence of from 1 to 5 per cent.

A decisive number of writers who have investigated the subject emphasize the high incidence with which carcinoma develops in pre-existing adenomas of the gland. In general, they report that ap-

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Hare and Warren, however, feel definitely that this group of tumors in children are true malignancies of the thyroid which arose in the gland. Warren (8) remarks of the age distribution of the Lahey Clinic cases "Increasing experience with thyroid malignancy has demonstrated to us the great fallacy of thinking that youthfulness of the patient precludes the presence of cancer of the thyroid." He and his co-workers point out that 16 per cent of their patients were less than 31 years of age and more than one-third were less than 41.

Sex Distribution—This is a point of some speculative interest. Eberts (4) puts the sex ratio in his cases as 5.6 female to 1 male. From these figures is deduced the conclusion that carcinoma of the thyroid is relatively more prevalent in men than in women inasmuch as the sex ratio in nodular goiter is found by Eberts to be 9 to 1. Pemberton's figures are 1.77 to 1 for malignancies and 5 to 1 for nodular goiters.

On the other hand, Clute and Warren in analyzing the Lahey cases found an incidence in malignancies of 7 females to 1 male, which is the same sex ratio for all cases of goiter operated on. From this similarity they infer the common origin of cancer in previously diseased thyroid glands.

Hyperthyroidism and Cancer—Pemberton found no constant change in the basal metabolism rate in cancer of the thyroid nor in any group of cancer of the thyroid. Dinsmore (12), in analyzing the previous history of malignancies, says that in approximately one-third of the cases patients will have some symptoms of over-activity of the gland.

Clute and Warren (8), in a discussion of this question, state that cancer may occur coincidentally with exophthalmic goiter. They believe that in these cases, of which they record four, the malignancy occurred in a coincident adenoma in the hyperplastic gland but that the hyperthyroidism was related only to the presence of hyperplasia in the otherwise normal tissue. They

have no evidence that hyperthyroidism arises as a result of the activity of the malignant thyroid tissue itself. There is evidence that some thyroid malignancies, however, have secretory power. They cite a case of Eiselsberg which developed hypothyroidism after excision of an adenomatous thyroid gland. The hypothyroidism was relieved after the development of a sternal nodule which proved to be metastatic adenocarcinoma of the thyroid. On removal of this nodule the patient again became a case of hypothyroidism.

Eberts quotes several authorities who support the view that hyperthyroidism may be the first sign of a malignant change in a benign goiter. He finds as yet no agreement on its frequency. Since the practice of determining the basal metabolism of all thyroid cases has become a routine, the percentage of malignant cases with hyperthyroidism has steadily risen.

Ewing is the authority most often quoted for the statement that the symptoms of Graves' disease may appear during the development of a malignant tumor and that the characteristic hyperplasia of Graves' disease may go on to malignant growth. Herbst (13) analyzed over 5,000 cases of exophthalmic goiter without meeting one case of malignant disease.

Clinical Diagnosis of Malignancies of the Thyroid—Most modern writers emphasize the fact that the so-called classical symptoms of cancer of the thyroid are those of the end-stages of this condition. A committee on thyroid tumors of the California Medical Association issued, in 1934 (14), a report of recommendations on treatment. They state concerning clinical diagnosis made before operation that the more certainly cancer of the thyroid can be diagnosed, the more hopeless is the prognosis. Findings suggestive of malignancy, fixation of the tumor to the trachea and surrounding tissues, hoarseness arising from involvement of the recurrent laryngeal nerve, dysphagia, local or radiating pain, enlargement of the regional lymph glands, all are dependent on exten-

proximately 90 per cent of cases originate in a pre-existing adenomatous goiter. However, Eberts (4) mentions several writers who cite cases of carcinoma of the thyroid which apparently occurred in previously normal thyroid tissue. He concludes that such cases do occur, but that in comparison to the number of carcinomas which arise in previously existing lesions, it is rare to find them.

Clute and Warren in a discussion of this question (8) say that the figures are open to a certain amount of question because of fallacious observations by patients. They find, however, that for the cases belonging to their pathologic Groups I and II, a pre-existent goiter was almost invariably present, while in Group III cases often no goiter was noted longer than a few weeks or months before operation.

Age at Onset of Malignancy—This question has received considerable attention because of its relation to the period of physiological activity of the thyroid gland and also because of the interest attached to several reported cases in children.

All authorities agree that the majority of cases occur in the fifth and sixth decades of life, past the age of greatest physiological activity of the thyroid and sex glands.

Because of the youth of the patient whose description I am appending to this paper, I have paid particular attention to reports of cases in children.

Kennedy (10), in 1935, reported on the cases of carcinoma of the thyroid in children found among the cases operated upon by Pemberton at the Mayo Clinic. In 276 operative cases he found one patient in the first decade and two in the second decade. He found six cases reported in the American literature in twenty years.

In a more recent report, Hare (5) found six cases of primary malignancy of the thyroid in children under fourteen years of age among 258 cases of children operated on at the Lahey Clinic. Three of these cases had previously been reported by Cattell in 1932 (11). Cattell noted the dissimilarity of his cases and concluded that those corresponding in type and

grade to malignancies in adults have similar clinical courses.

Hare reports excellent results from combined surgery and radiation in his cases, especially so since his plan of radiation was changed by increasing filtration and protracting treatment to allow of larger total dosage with less skin damage. This discussion will be considered further in the section on radiation.

Hare found that in the five living cases there has been no deleterious effects on growth, all the children having developed normally despite radical surgery and heavy doses of radiation. The cholesterol determinations have remained within normal limits and there have been no clinical symptoms suggestive of myxedema. On the contrary, in the adult cases about 15 per cent have developed a mild degree of myxedema.

In an interesting discussion of Hare's paper, Portmann criticizes the diagnosis in the cases reported by Hare and other cases in children reported as thyroid carcinoma. He raises the following points:

(1) They are usually described as originating in papillary cyst adenomas, aberrant thyroids or thyroglossal duct. All these terms, Portmann maintains, mean that the growths originated in derivatives of the pharyngeal pouch.

(2) Distant metastases did not develop in a single instance although many patients had what were looked upon as recurrences.

(3) Not one patient died prior to the reporting of the case in the literature, and some are still well after a number of years.

For these reasons Portmann questions the propriety of including these juvenile cases as malignant thyroid gland tumors *per se*, despite their similarity of histological appearance to adult malignant thyroid tissue. He claims that their morphology is essentially that of a papillary adenoma, that they may have a histological appearance which may be interpreted as malignancy but that they remain localized and do not destroy vital functions and, therefore, are not cancers of the thyroid.

metastasizing goiter, concluded that few if any of the cases had been proved to be benign. Berard and Dunet maintain that even though not demonstrated, yet there must have been in these cases a primary lesion in the thyroid gland.

A potent source of confusion in terminology has been attempts to make classifications to suit various theories as to the etiology of these tumors. Haagenson concludes that our knowledge of the etiology of thyroid tumors is yet too meager to allow their classification according to their development from adult thyroid follicles, from fetal adenomas or otherwise. Ewing believes it more probable that many carcinomas arise from adult follicles, while Wolfier and Langhans assumed all the epithelial tumors of the thyroid to arise from fetal cell masses.

Another source of confusion is the question of the mesoblastic or epithelial origin of certain types of tumors. One of these is the small round-cell carcinoma (carcinoma simplex). Ewing, Haagenson, and Warren all deny the mesoblastic origin of these tumors. They are to be differentiated from lymphosarcomas (which they greatly resemble), because of the nature of the nuclei, their tendency to clumping of cells in certain areas, the nature of their metastases, and their response to radiation.

Another type of tumor about which there is dispute as to the exact nature of the tumor cell is the giant-cell carcinoma. Warren (8) says, "These tumors present bizarre pictures with almost every conceivable size and shape of cell, with marked variation of nuclear structure." Certain European authors dominated by theoretical considerations of the mesoblastic origin of large classes of thyroid tumors have confused the terminology. Berard and Dunet, for instance, include 17 different types originating from epithelium, connective tissue, and mixed tissue.

Ewing (16) believes that notwithstanding the wide acceptance of numerous reported cases of sarcoma, there is strong reason for believing that the great majority of these tumors are of epithelial origin.

Pemberton (1) states that although the incidence as reported in the literature is probably far too high, sarcoma nevertheless has been positively diagnosed at the Mayo Clinic in four instances in the course of pathologic examination of approximately 40,000 thyroid glands. All of the four patients died within a year of operation.

The pathological classification found adequate for the grouping of all cases of primary malignancy of the thyroid used at the Mayo Clinic (Pemberton) is very simple, with only five classifications:

- (1) Papillary Adenocarcinoma,
- (2) Adenocarcinoma in Fetal Adenoma (Malignant Adenoma),
- (3) Diffuse Adenocarcinoma,
- (4) Epithelioma,
- (5) Sarcoma

This grouping has been adequate for all cases of primary malignancy of the thyroid gland.

The classification of Allen Graham, as used at the Crile Clinic, lists several subdivisions as varieties of sarcoma regarding which there is controversy, with the majority opinion leaning toward their epithelial origin. It is as follows:

- (1) Sarcomas
 - (a) Lymphosarcoma
 - (b) Spindle-cell Sarcoma
- (2) Mixed Tumors
 - (a) Carcinoma-sarcoma
- (3) Carcinomas

(a) Scirrhus Carcinoma	} not in Adeno-
(b) Adenocarcinoma	
(c) Papillary Carcinoma	} in Adenoma
(d) Malignant Adenoma	

At the thyroid clinic of the Montreal General Hospital, Eberts uses a classification containing subgroups of epitheliomas and endotheliomas.

At the New York Memorial Hospital, Ewing has tried to reduce classification to its simplest form by combining several closely related forms under one heading. Haagenson observes that our knowledge of etiology is yet too meager to permit of classification under the precursal cell forms. Their classes are as follows:

sion of the malignant tissue beyond the capsule. Other signs, which are not constant, are rapid increase in size and hard consistency on palpation—the latter without evidence of calcification on x-ray examination. From the difficulties of early clinical diagnosis and the further difficulties of accurate pathologic examination, it follows "that the problem is one of prophylaxis and prevention rather than diagnosis and cure."

Almost all five-year cures are among patients whose first diagnosis of malignancy was made at the operating table or in the laboratory. The California report recommends operative treatment in all cases of nodular goiter in which—

- (1) Recent growth has taken place in a previously stationary gland,
- (2) Fixation of the goiter to the trachea or surrounding tissues has taken place,
- (3) Consistency of the goiter is hard and calcium deposits are not demonstrable by x-ray examination,
- (4) There is a history of pain, dysphagia, or respiratory difficulty in a previously symptomless goiter.

Clute and Warren give the following as the early significant and suggestive signs of thyroid malignancy:

- (1) The slow growth of an adenoma over a period of weeks and months,
- (2) Increasing firmness of the tumor and the occurrence of a sense of pressure in the neck, with lack of freedom of movement.

The Question of Operation for Benign Adenoma—Pemberton states the generally accepted view that because of the definite risk of carcinoma and the low operative risk and morbidity and the small incidence of recurrence, operation should be at least advised in all tumors of the thyroid gland.

Crile and Portmann (12) state that it is a safe general rule for surgeons to consider as inoperable from the standpoint of curability those cases in which there are clinical evidences that the growth has extended through the capsule of the thyroid,

this invasion being manifested by fixation of the gland, by involvement of the lymph nodes, or by metastases.

Eberts quotes De Quervain as saying, "Cure rather than diagnosis should be the surgeon's goal, and thus can be obtained only if the operation is undertaken early and on no more substantial ground than suspicion. By far the greater number of cases reported as permanent cures are those in which malignancy was not even suspected when operation was performed, the clinical diagnosis being simple adenoma."

Classification of Carcinoma of the Thyroid—As the pathologic grouping of carcinoma of the thyroid is intimately bound up with the questions of radiosensitivity and prognosis, it is unfortunate that there should be such a bewildering array of classifications. Graham's reasons for this confusion have been previously cited.

Haagenson (2) mentions the extreme morphological variation existing in these tumors and the great difficulty of differentiating between benign and malignant growth. He cites Wilson's series of 97 clinically malignant cases of which 23 were passed as benign by pathologists. On the other hand, Graham reviewed in 1924 (3) some 108 cases which he formerly had designated as malignant. Applying his criterion of malignancy, blood vessel invasion, he found that 43 of these cases did not have evidence of malignancy.

The existence of "benign metastasizing goiter" has been denied by most of the later authors. Pemberton considers that this idea gave rise to confusion by putting carcinoma of the thyroid in a special category not shared by carcinomas elsewhere. Simpson (15) analyzed reported cases of metastases from apparently benign thyroid tumors. He maintains there is no such entity as the benign metastasizing goiter and shows that there exists in such cases undetected areas of adenomatous proliferation. Eberts mentions similar reports from European literature, notably Delannoy and Dhallum, who, from an analysis of 72 cases reported as benign

cinoma and the non-papillary or alveolar. The papillary forms differ from the malignant papillary cystadenoma in their multiple epithelium and in the greater variability of their cells, both in size and shape. The evidence of invasion is much more frank.

The alveolar forms include several types which grade so imperceptibly from one to another that any separation into classes would be arbitrary.

Although adenocarcinoma of the thyroid is relatively slow growing, recurrences are frequent and there is a high mortality. Clute and Warren report that 54.8 per cent of the group of 31 patients which they followed have died, while another 14 per cent show evidence of recurrence.

X-ray treatment in this group is believed to have added to the length of life of patients who had recurrences. Inoperable tumors have become operable after intensive treatment.

Haagenson reported on cases corresponding to this group: a 71 per cent primary regression, with a mortality of 57 per cent.

Group III. In this group Warren and his associates place the most highly malignant tumors with hopeless prognosis. They subdivide the group into four classes:

(1) Squamous-cell or epidermoid carcinoma, (2) Carcinoma simplex or small-cell carcinoma, which may be either compact or diffuse, (3) Giant-cell carcinoma, often called "carcinosarcoma", (4) Extremely rare fibrosarcoma.

As mentioned previously, there is dispute over the exact nature of the second and third classes, many of these cases being classified as sarcoma by other authors.

These tumors clinically are distinguished by their rapid growth with pressure symptoms. Clute and Warren in common with other authors emphasize the hopeless prognosis of these Group III growths. However, the recent report of Hare (18) gives grounds for believing that with the most modern methods of intensive therapy, types formerly considered radioresistant

may respond favorably. He reports great progress in the treatment of Group II and Group III tumors. He finds that the two varieties of small-cell carcinoma and giant-cell carcinoma decrease in size more rapidly than do the other types, but at the same time require a larger dose to prevent recurrence. He believes that the dosage delivered to the tumor bed by older methods of treatment has been insufficient. He finds that with modern shock-proof apparatus the use of a cone directly on the skin with no overlapping allows a larger dose to be given. He gives 1,500 r to each side of the neck through 80 sq cm portals, each area receiving six treatments of 250 r each. The dermatitis appearing in from 10 to 14 days clears in about three weeks' time. The reaction in the upper respiratory tract is not alarming with proper care. I feel that this routine could be improved by increasing the filtration from 0.5 mm Cu to 2 mm Cu, with an increase in the total dose. This would require more protracted treatment.

The recent rapid progress in radiation of these malignant types can be appreciated by contrasting this recent report of Hare with the 15-year-old report of Haagenson previously mentioned. In discussing the treatment of these cases, the latter says: "In anaplastic, rapidly growing fatal types, the giant-cell carcinoma and the small round-cell carcinoma, external radiation may be tried, but as no one has yet reported beneficial results it should not be given to the point of making the patient uncomfortable."

The papers of Portmann (12), Bowing (19), Pemberton and Fricke (20), Craver (21), and Haagenson (2) discuss the treatment of carcinoma of the thyroid of various types, giving criteria of operability and the further treatment of both operable and inoperable cases by radium and x-ray.

Bowing divides his cases into operable, borderline, inoperable, and recurrent. His radiotherapeutic program is formulated after consideration of clinical and surgical opinion, histopathology and extent of local and distant destruction or impairment.

- (1) Papillary Cystadenocarcinoma (30 per cent),
- (2) Small Alveolar, Large-cell (Hurthle Cell) Carcinoma (6.6 per cent),
- (3) Adenocarcinoma (46.7 per cent),
- (4) Giant-cell Carcinoma (10 per cent),
- (5) Small Round cell Carcinoma (6.6 per cent)

The Question of Radiosensitivity of Thyroid Tumors—Haagenson (2) noted that in the Memorial Hospital series primary regression was obtained only in the first three of the above groups, never in the last two. He finds that the malignancy and anaplastic character of the tumors increase in the order of classification. Their radiosensitivity decreases as their anaplasia and rapidity of growth increase. The most rapidly growing and anaplastic types appear to be uniformly radioresistant. In an interesting discussion of hitherto proposed laws of radiosensitivity such as the law of Bergonié and Tribondeau and similar theoretical statements, Haagenson points out the unsatisfactory clinical applications in tumors of various regions. He finds that these proposed laws governing radiosensitivity fail because the phenomena involved are a great deal too complex to be envisaged by a simple statement of one or two factors, such as anaplasia, rapidity of cell division, etc. He proposes a scheme for the estimation of the radiosensitivity of tumors involving a study of the constitutional factors such as age, development, nutrition, hemic status, systemic disease, secondly, local factors—infection and blood supply, thirdly, the factors inherent in the tumor—rate of growth, morphological character, and anatomical situation.

The classification of thyroid malignancies developed by Shields Warren with Clute and Smith (7, 8, 9, 17) and used in the Lahey Clinic series is based on the relative radiosensitivity of definite histological types and appears to me to be the most useful in promoting co-operation between the surgeon and the radiologist. Thyroid cancer is divided into three main clinical divisions. In Group I is the pa-

tient with low or potential malignancy, in Group II we have the patient with definite but not hopeless malignancy, and in Group III we have the patient with severe and usually incurable malignancy.

Group I is divided pathologically into two classes.

(1) *Adenoma with Blood Vessel Invasion*—This is the type of tumor in which Allen Graham made the important contribution of proposing blood vessel invasion as an index of malignancy. In 1,114 adenomas examined by Warren, 31 per cent showed varying degrees of invasion of blood vessels and 10 per cent of these patients died of metastases. Adenomas in which fully developed carcinoma is present are not included in this group. The adenoma is of usually undifferentiated type, either embryonal or fetal.

(2) *Papillary Adenocystomas*—These tumors are regarded as malignant if they show evidence of capsule, blood vessel, or lymphatic involvement. Origin from aberrant thyroid tissue is not infrequent. This tumor has a characteristic histological appearance because of its tracery of branching papillæ. It is characteristically radiosensitive because of its papillary nature.

Warren states that both types of tumors in Group I are susceptible to x-ray treatment and that extension of the growth in many recurrent cases has been markedly slowed and limited by persistent x-ray treatment after operation.

Patients dying of cancer of the thyroid of the Group I types have been those with clinically obvious cancer which was far advanced at the time of the original operation. In none of the patients of this group which Clute and Warren followed, has any recurrence appeared when the patient was well to clinical and x-ray examination a year or more after the original removal of the thyroid tumor.

Group II. In this group are placed all cases of adenocarcinoma of the thyroid. There are wide morphological variations but the group may be divided histologically into two forms, the papillary adenocar-

invasion of the tumor X-ray treatments were given daily with oil-cooled type of shock-proof apparatus with 200 kv p, 2 mm of copper and 1 mm of aluminum filtration, 15 ma, at 50 cm focal-skin distance. The daily dose consisted of 200 r units delivered in 27 minutes to the right and left sides of the neck alternately through a 15 × 15 cm square portal. This gave a dose of 1,500 r to each side. One week following her last treatment the patient returned to the hospital with restlessness, dysphagia, and a sense of fullness in the throat. She could take liquids only. The mucous-membrane reaction and skin reaction were very moderate. Apparently this dosage might have been considerably extended to the point of producing the extreme reaction of the Coutard technic but I thought it best to adhere to the dosage given by Hare. Evidently the reaction, using 2 mm of copper filtration, was much milder than that described by Hare, using 0.5 mm Cu.

The patient was in a restless condition during the period of reaction and her basal metabolic rate was plus 49 per cent. After a week's rest she was comfortable and her metabolism had dropped to minus 11 per cent. It is now six months since her operation. Her basal metabolism rate is still minus 11 per cent. Her weight has increased 26 pounds and her height one inch. She suffered from a psychic depression post-operatively and left school because of the fancied hopelessness of her condition. She seems to be getting over this stage now. Clinically she is in the best of health, with no such evidence of thyroid deprivation as would require substitution therapy. There is no evidence of recurrence to date.

SUMMARY AND CONCLUSIONS

A survey of the recent literature from several of the largest American thyroid centers has been made in regard to the incidence, diagnosis, histopathology, and treatment of carcinoma of the thyroid. A comparison of pathologic classifications in use, with especial attention to the

question of radiosensitivity, leads to the conclusion that statistical study and treatment could be advanced by the adoption of a standard classification of the type formulated by Warren and his associates. The question of juvenile malignancies of the thyroid has been considered and a case of malignancy in an adolescent reported. The conclusion is derived that the most modern methods of protracted radiation therapy have apparently yielded better results than older methods in cases considered intractable to treatment.

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The details of methods of radium therapy used at the Mayo Clinic are given by Pemberton and Fricke

No pressure signs except a slight cough. She was recovering from an otitis media. The girl was nervous and depressed. She

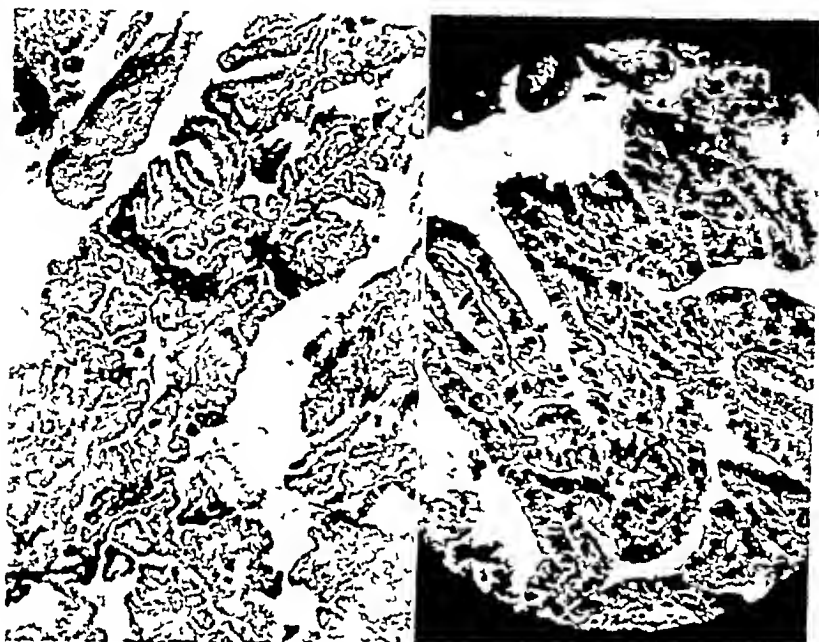


Fig 1

Fig 2

Figs 1 and 2 Photomicrographs of sections of tissue from case reported

All these papers emphasize the necessity for co-operation between the surgeon and the radiologist. It is recognized that surgery alone is not justified even if the growth is apparently entirely removed. Irradiation alone is a poor policy except in totally inoperable cases. Pemberton reports 10 per cent of cures in totally inoperable cases treated by radiation therapy alone.

CASE REPORT

A report of a case is appended, of interest because of the occurrence of carcinoma of the thyroid in the early age group.

E G, white American girl of 15, normally developed, was admitted to the service of Dr E P Fish at the Sisters' Hospital, Waterville, Maine, with a protuberant tumor over the thyroid region which she had noticed to be increasing in size for the past four years. The tumor was in the midline, moderately hard, not fixed

had a tremor of the tongue and a basal metabolic rate of plus 46 per cent before operation.

The pre-operative diagnosis was fetal adenoma. Malignancy was not seriously considered before operation. At operation a large cystic adenoma was found, involving the isthmus and a large part of the right lobe. This was dissected as completely as possible, although the capsule could not be entirely freed posteriorly. A subtotal thyroidectomy was performed.

On section the tumor proved to be a definitely malignant papillary cystadenoma. The diagnosis was checked by Dr Shields Warren and Dr Howard Clute who assigned the tumor to Group I of their classification. The wound healed cleanly with an uneventful post-operative course and radiation therapy was started two weeks post-operatively.

X-ray examination of the neck and thorax showed no evidence of extension or

THE TRANSMISSION OF AN INVISIBLE RADIATION THROUGH VARIOUS CHEMICAL SOLUTIONS AS RECORDED BY THE INFRA-RED PLATE

By LEO C MASSOPUST, *Milwaukee, Wisconsin*

Department of Anatomy, Marquette University School of Medicine

THE probable value of infra-red photography to the radiologist prompts this further study of the physical properties of the infra-red radiation. In previous reports in RADIOLOGY by the author (5 and 7), the methods of simultaneous infra-red roentgen photography and photographic images obtained in total darkness by both penetration and reflection are described.

The purposes of this study are to demonstrate first, the properties of penetration through various colored chemical solutions by an invisible radiation from a source of ordinary light and, second, the absorption or "stopper" action of the various salts of copper.

In order to clarify to some degree the experimental evidence under discussion, it seems that a few remarks on the general physics involved in this problem might be of interest to the reader. According to accepted theories on the constitution of matter, it is assumed that all matter is made up of a very large number of infinitely small particles or molecules. The molecules are more or less independent of one another when the matter is in the gaseous state, but in the liquid and the solid states of matter they lose some part of their independent character. The molecules are also supposed to be subdivisible into atoms. These atoms and molecules, or some portions of them, are also supposed to be in a violent state of vibration, oscillation, or agitation which is associated with what we call heat and light.

These radiations, however, only become evident to our senses when the waves impinge on sympathetic particles or molecules of matter. That is, if the molecules are so constituted that they, or some portion of them, respond to the impinging waves, the waves are extinguished and vi-

bration induced. In other words, if the natural period of vibration or motion of the molecules is "in tune" with the impinging

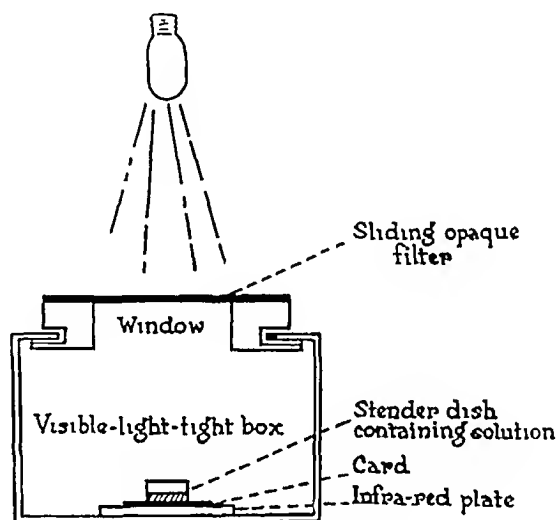


Fig. 1 Diagram of photographic apparatus

waves, vibration is induced. Otherwise the waves pass on or are reflected, apparently having no effect on the molecules.

The wave theory of light assumes that the disturbance known as light consists of a wave motion in a medium known as the ether. In the ether of space, waves of all lengths travel with the same velocity.

In 1850, Foucault (8) demonstrated very definitely that the velocity of light in water is less than in air, though he made no estimate of the ratio. Michelson, however, measured the relative velocity of light in air and water and found the ratio to be 1.331. Michelson (8) has also shown by direct measurement that the velocity of red light is 1.4 per cent greater than that of blue light. Dispersion is therefore due to the unequal retardation in the speed of transmission of the different colors through transparent media. The violet rays, which are the shortest waves in the visible spec-

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solutions with greater velocity than through the surrounding air. In Figure 3 the white circular area, which is the area covered by the dish and its contents, reveals this effect rather vividly. The printed matter on both sides of the card is also plainly visible.

The color dyes listed in Table I range from red to violet. In each case the dish, containing 20 c c of a 1 per cent aqueous solution of the dye, is placed inside the box in the same manner as mentioned above.

TABLE I —COLOR DYES IN SOLUTION

1% Azo Fuchsin	Transparent
1% Carmine	Transparent
1% Rhodamine	Transparent
1% Fast Light Orange	Transparent
1% Thioflavine	Transparent
1% Neptune Green	Transparent
1% Methylene Blue	Transparent
1% Victoria Blue	Transparent
1% Methyl Violet	Transparent

The photographic effect obtained with each of the color solutions shows no variation in the degree of transmission of this invisible radiation. All of the dyes transmit the radiation with the same velocity. The same dyes in solution are then interposed between the source of visible light and the box. The use of these color solutions in this manner obviously changes the wave length of the radiation striking the filter in the window of the box. The box is then exposed to the same intensity of light for four seconds, the same exposure time as is used in the previous experiment. Again there is no variation in the transmissibility of the solutions inside the box. Hence, the changing of the wave length of the visible light source from the violet (3,800 Å) to the red (7,800 Å) does not alter the effect

TABLE II —METALLIC SALTS IN SOLUTION

1% Copper Sulphate	Opaque
1% Copper Chloride	Opaque
1% Copper Acetate	Opaque
Benedict's Solution	Opaque
1% Gold Chloride	Transparent
1% Lead Acetate	Transparent
1% Lead Acetate (stained blue)	Transparent
1% Silver Nitrate	Transparent
1% Nickel Sulphate	Transparent
1% Chromic Acid	Transparent
1% Zinc Acetate	Transparent

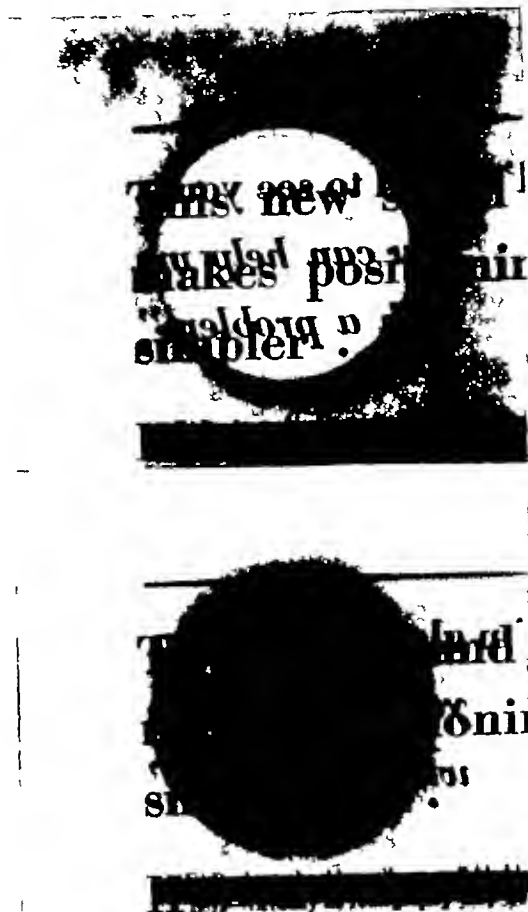


Fig 3 (above) Infra red photograph taken in total darkness. A card, having printed matter on both of its sides and a Stender dish containing 20 c c of any of the solutions listed in Tables I-III, with the exception of the copper solution, are placed on an infra red plate inside the visible-light-tight box. The box is then exposed to the illumination from a 500 watt tungsten bulb for 4 seconds. Contact print.

Fig 4 (below) Infra red photograph taken in total darkness. A card having printed matter on both of its sides and a Stender dish containing 20 c c of a copper solution are placed inside the visible-light tight box and photographed with the same technic as is used in Figure 3. Contact print.

of the photographic image obtained inside the box.

The tabulation of the photographic results obtained with various metallic salts in solution (Table II) reveals that thus far copper is the only metal in solution which acts as a "stopper" of this invisible radiation. There is no activation of the emulsion of the infra-red plate in the circular area covered by the dish containing the copper solution (Fig 4). All of the other

trum, suffer the greatest retardation, or travel more slowly than red, when they enter an optically denser medium. Physi-

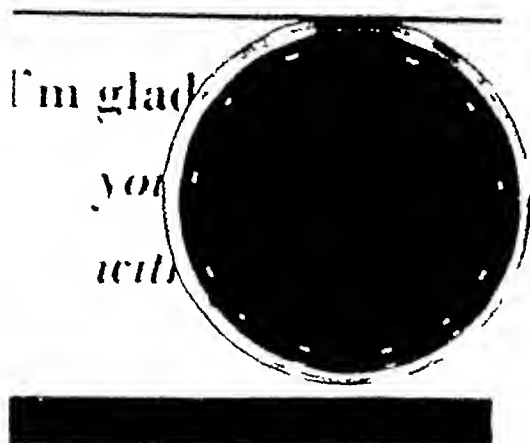


Fig. 2 Ordinary photograph taken with reflected light of a card and a Stender glass dish containing 20 c.c. of azo-fuchsin. Illumination from a 500 watt tungsten bulb. Eastman portrait film. Exposure time 4 seconds at f 22. Contact print.

cally the differences in spectral colors are differences of wave length, the short waves suffering greater diminution of velocity in a dense transparent body than the long waves. Hence the ratio of the velocity of light in air to its velocity in a second medium is called the *Index of Refraction* of the second medium, as referred to air.

Materials and Methods—The box shown in the diagram (Fig. 1) is constructed of wood and lined with lead. The filter which closes over the window in this box is a photographic film holder slide which serves as a protective measure when using ordinary emulsions. Hence all visible light is prevented from entering the inside of the box. This slide, however, becomes very transparent when used in conjunction with the infra-red emulsion, for even the invisible emanations from subdued visible light will cause fogging of the plate. An Eastman infra-red plate, type 1R, is placed in the bottom of the box with the emulsion side directed upward. A card having

printed matter on both of its sides is laid on the plate in contact with the emulsion. This card is used in this way to demonstrate the penetrating effect of the invisible radiation entering the visible-light-tight box. A Stender preparation dish containing 20 c.c. of a 1 per cent aqueous solution of the chemicals listed in Tables I, II, and III is placed on the card. Figure 2 is a contact print of an ordinary photograph taken with reflected visible light, showing the arrangement of the photographic plate, the card and the dish containing the solution, as it is placed inside the light-tight box. The printed matter on only one side of the card is recorded in this ordinary photograph. The window is then closed by the sliding filter and the box exposed to the illumination from a 500 watt tungsten bulb with the illumination directed over the closed window for four seconds (Fig. 1). The invisible rays emanating from the tungsten lamp penetrate this opaque sliding filter and activate the emulsion of the infra-red plate inside the box. The plate is then developed and handled in total darkness. Figures 3, 4, 5, and 6 are contact prints from negatives which have been activated by this invisible radiation. The author has discussed various applications and methods of infra-red photography in previous publications (1, 2, 3, 4, 5, 6, and 7).

All of the photographs presented in this report are contact prints.

Observations—Figure 3 is a contact print illustrating the photographic effect obtained with each solution which transmits the radiation entering the box. It is to be observed that this radiation must pass through the color dye and through the bottom of the glass dish before reaching the emulsion. Clear glass is supposedly as opaque to radiation from a non-luminous source as black glass is to visual radiation. In spite of this apparent obstruction, the radiation is recorded on the emulsion of the plate covered by the dish before it is recorded on the surrounding unobstructed area. It is obvious, therefore that this radiation is passing through each of these

acts as a "stopper" of this transmission phenomenon. Copper in solution is the only "stopper" of this radiation which has thus far been found.

4 Atomic weight and density of the molecules in a solution, apparently have no effect on the transmission of this invisible radiation.

5 The results of the experimental evidence presented would indicate that this radiation is confined to a rather narrow band in the infra-red region.

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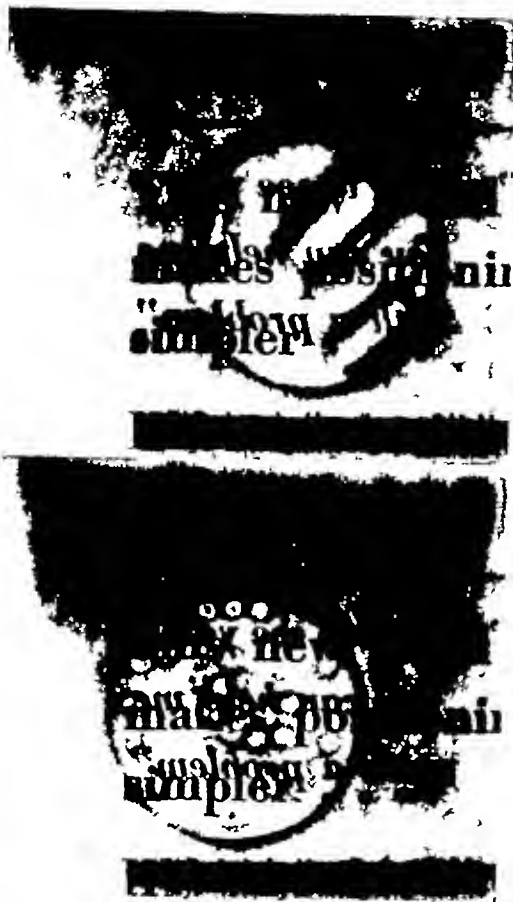


Fig 5 (above) Infra red photograph of pieces of solid glass rod The same photographic technique is used as in Figures 3 and 4

Fig 6 (below) Infra red photograph of glass beads The same photographic technique is used as in Figures 3 and 4

metallic solutions listed in Table II are very transparent and show no variation in the degree of transmission. In view of these observations it seems logical to conclude that this radiation must be confined to a rather limited region in the infra-red band. Landauer (9) states that the absorption spectra of copper solutions are not very characteristic because almost all of them are two-sided, that is, there is absorption in both the violet and red ends of the spectrum. This observation is interesting, for we know that the infra-red plate is also sensitive in both the violet and red ends of the spectrum. Thus it would seem that there is possibly a definite relationship between the facts that the absorption spectra

of copper and the sensitivity of the infra-red plate are in the same regions of the spectrum

TABLE III — MISCELLANEOUS CHEMICAL SOLUTIONS

1% Sodium Iodide	Transparent
1% Sodium Bromide	Transparent
1% Sodium Chloride	Transparent
1% Alum	Transparent
1% Sucrose	Transparent
Tap Water	Transparent
Boiled Water	Transparent
Hydrogen Peroxide	Transparent
Alcohol	Transparent
1% Sodium Carbonate	Transparent
1% Potassium Permanganate	Transparent
1% Quinine Bisulphate	Transparent

Table III is a tabulation of the results obtained with miscellaneous chemical solutions. It is noted that sodium iodide and sodium bromide, which are opaque to the roentgen ray, transmit the radiation entering the box readily. The solutions of alum and sucrose which supposedly absorb about 88 per cent of the non-luminous radiations from a source of light, are also transparent to the invisible radiation entering the box.

The photographic effect of the refraction of pieces of solid glass rod and glass beads is shown in Figures 5 and 6.

The author gratefully acknowledges the aid of Mr. Charles R. Neterval, of the Department of Biochemistry, in the preparation of the chemical solutions.

SUMMARY

1. An invisible radiation having properties of penetration is obtained from an ordinary light source, and seemingly is transmitted through various chemical solutions with greater velocity than through air.

2. The filtering out of various regions of the visible spectrum in the visible light source does not alter the photographic effect obtained inside a visible light-tight box.

3. A 1 per cent solution of copper sulphate, copper acetate, or copper chloride



Fig 1

Fig 2

Fig 1 Inspiratory phase of case of mediastinal hernia due to artificial pneumothorax

Fig 2 Expiratory phase same case Note greater prominence of hernia showing it to be a pulsion type

on which side of the mediastinum the force causing the hernia is applied

The practical application of these physical forces is of considerable interest to us and deserves a few words. Let us take first the most usual mechanism as seen in mediastinal hernia resulting from artificial pneumothorax. In this case the air introduced into the pleural space is trapped there and is not in direct communication with the outside atmosphere through the trachea. During inspiration this air occupies a smaller percentage of the total volume of the hemithorax in which it lies than it does during expiration. Therefore, this trapped air when its volume is greatest during expiration, raises the pressure in the hemithorax above that of the other side, and a push is exerted against the mediastinum. If the mediastinum is labile, this push shifts it *in toto* toward the opposite side, if the entire mediastinum is rigid, then there is no shift, if, however, the "weak spot" is less resistant

to pressure than the mediastinum as a whole then we will have the development of a mediastinal hernia. If such a case is observed at the fluoroscope or films are made at the end of inspiration and of expiration, it will be seen that the line marking the limits of the hernia moves during respiration and bulges farthest into the contralateral hemithorax during expiration.

This situation is seen in Figures 1 and 2 which are films taken in inspiration and expiration, respectively, of a case of mediastinal hernia due to artificial pneumothorax. The intrapleural pressures on the right at the time these films were taken are as follows: On quiet respiration from 0 to -1 cm of water, on deep inspiration $-1\frac{1}{2}$ cm and on forced expiration $+5$ cm. We see in this case that during inspiration the air trapped in the right pleura occupies the smallest percentage of the total volume of the hemithorax and the intrapleural pressure is most negative, the line limiting

MEDIASTINAL HERNIA

By RICHARD T. ELLISON, M.D., Assistant Professor of Medicine, Graduate School,
University of Pennsylvania, Philadelphia

From the Pulmonary Clinic, Graduate Hospital, Philadelphia, and Home for Consumptives,
Chestnut Hill, Pa.

HERE has been little in the American literature of the past few years on the origin and development of mediastinal hernia or pneumatocele. During this time, however, the Italian and French schools have devoted considerable attention to this subject. Besta (1) has recently published a comprehensive review of the Continental literature with considerable original data, but there is little available in English. I, therefore, have thought that it would be of some interest to review the origin of this condition, and to consider the mechanism of its development, presenting several cases illustrating the various types.

First, just what do we mean by the term *mediastinal hernia*? It can be defined as the projection through the mediastinum of one pleural space into the other hemithorax. It was only with the development of artificial pneumothorax therapy coupled with the greater use of the x-ray both for fluoroscopy and plate work, that the possibility of such a condition was appreciated. Artificial pneumothorax is still the most common cause of hernia of the mediastinum, although it does occur in spontaneous pneumothorax and, as we shall see, occasionally in the absence of pneumothorax. The walls of the hernial sack as it protrudes through the mediastinum are formed by the parietal pleura lining each hemithorax. This is seen as a thin line on the film or the fluoroscopic screen, protruding into the normal lung-field.

Second, just where does this hernia through the mediastinum occur? Anatomically there are two so-called "weak spots in the mediastinum." The first

and the most important of these lies behind the sternum above and in front of the heart at the site of the atrophied thymus. The second lies below and posteriorly and is a space bounded below by the crura of the diaphragm, posteriorly by the spinal column, and in front by the esophagus as it bends forward to pass through the diaphragm. Once a small wedge has been driven through one of these spaces, however, the margins may be spread until the hernia occupies an area far greater than the original "weak spot."

Third, how does such a herniation of the mediastinum come about? What are the physical factors that lead to its development? It takes but little consideration to realize that the force that causes the hernia is a difference in pressure in the two halves of the thoracic cage and that this difference in pressure is the result of a difference in volume. It is also quite obvious that the mediastinum itself must be considerably more rigid than the "weak spot" otherwise the mediastinum as a whole would be shifted toward the hemithorax with the lowest pressure. It is also evident that if volume plays any part in the development of this condition then there must be a change in the size of the herniation during the different phases of respiration dependent on the changes in the size of the thorax as a whole. Also it is evident that a difference in pressure on the two sides of the mediastinum can be brought about in either of two ways: either the pressure on one side can be raised above the normal or mean, or the pressure on the other side can be lowered below that mean. We thus have either a pulsion or a traction hernia, depending



Fig 5

Fig 5 Pulsion hernia due to spontaneous high pressure pneumothorax



Fig 6

Fig 6 Traction hernia in same case after closure of pleural tear and partial absorption of air

ing, as we usually do not see herniation of the opposite lung through the mediastinum in this condition. Conclusion obstructive emphysema of the left lung with herniation of the right lung through the mediastinum."

When I saw the child in consultation my findings were "An atelectatic condition of the left lower lobe. This may be the result of obstruction in the left lower lobe bronchus. There is a slight compensatory emphysema in the left upper lobe. I do not believe there is any obstruction in the left main stem bronchus or any obstructive emphysema in the left lung. There is a possibility that the obstruction of the left lower lobe may be the result of the pressure by a tuberculous mediastinal gland."

The reason for these conclusions was chiefly that it is impossible to get a traction type of mediastinal hernia from an obstructive emphysema in cases in which the lung is over-distended. Also we had clinical evidence of atelectasis in the left lower lobe. Overholt (2) has pointed out that when atelectatic, the left lower lobe may be entirely hidden by the heart, the

only clue being a compensatory emphysema of the upper lobe. That is what we have here, I believe, only the compensatory emphysema was not sufficient to restore all the loss of volume, therefore, part of the right lung was drawn through the mediastinum.

Bronchoscopy was done in this case, and the report was "Purulent tracheo-bronchitis with considerable edema and swelling of the mucous membrane of the left bronchus." Following this bronchoscopy the fever abated, physical signs disappeared, and another x-ray examination four days later showed disappearance of the hernia and a normal left lung.

These two cases illustrate the pulsion and traction type of mediastinal hernia through the anterior "weak spot." The following cases show the practical value of differentiating these two types of hernia.

Figure 5 is a film of a man with a high pressure pneumothorax on the right side. At this time the intrapleural pressure on the right side was 0 + 10 cm of water, and we recognize a large pulsion hernia of the right pleural sack into the left hemitho-



Fig 3

Fig 3 Inspiratory phase of traction type of hernia. Note degree of herniation

Fig 4

Fig 4 Expiratory phase note disappearance of hernia.

the herniation lies against or is lost in the shadow of the mediastinum. During expiration this line moves away from the mediastinum into the contralateral lung-field and the intrapleural pressure becomes more positive. This may occur even while the intrapleural pressure is negative during quiet respiration because the damage has been done by the high positive pressure developed during cough. In this sort of case, then, the bulging is most apparent during expiration, and we are dealing with the pulsion type of mediastinal hernia.

The traction type of hernia is much less common. Here the force causing the herniation is due to a loss of volume of one lung and a great increase in the negative pressure in that hemithorax so that the lung from the normal hemithorax is drawn through the mediastinal "weak spot." This loss of volume is usually the result either of fibrosis or atelectasis in the involved hemithorax. Figures 3 and 4 are films taken in inspiration and expiration of a patient showing this type of mediastinal hernia. This case is extremely interest-

ing from several angles. In the first place it is the only case of hernia of the mediastinum in the absence of pneumothorax that I have seen personally. In the second place, it was the confusion of ideas arising from the original x-ray report that stimulated my interest in this subject.

The story, in brief, is as follows. The child was admitted to the hospital after an illness of two days, with cough and fever. The resident made a diagnosis of pneumonia or bronchial obstruction of the left lower lobe. The chief on the service made a diagnosis of bronchopneumonia. The Mantoux test was strongly positive. The x-ray report on these films was as follows:

"Inspiratory phase of respiration demonstrated marked shift of the heart and mediastinum to the left, with herniation of the right lung through the mediastinum. During the expiratory phase the right lung returns to its normal position. Fluoroscopically it was noted that during the expiratory phase the left lung remained aerated and the heart shifted back to its normal position. This pathological physiology is indicative of an obstructive emphysema in the left main stem bronchus of long stand-

All these cases have been of herniation through the anterior "weak spot." Figure 9 shows the expiratory phase of a case with artificial pneumothorax and herniation through the lower posterior "weak spot." Here we see that the position of the herniation differs from that seen in the previous cases, a fact much more easily appreciated on fluoroscopic examination. Herniation of this type, in the presence of massive pleural effusion, is the probable explanation of the contralateral paravertebral triangular area of impaired resonance known as Grocco's sign.

SUMMARY

Attention is called to the fact that mediastinal hernia occurs through one of two "weak spots" in the mediastinum, as the

result of differences in intrathoracic pressure in the two hemithoraces, due to difference in volume.

That the degree of herniation varies with respiration and, therefore, must be studied in inspiration and expiration.

That there are two types of herniation. First, a pulsion type in which the hernia is more prominent in expiration. Second, a traction type in which the hernia is more prominent during inspiration.

1614 Locust St

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Fig 7

Fig 7 Inspiratory phase showing mediastinal hernia in case of bilateral pneumothorax. Note greater prominence of hernia.

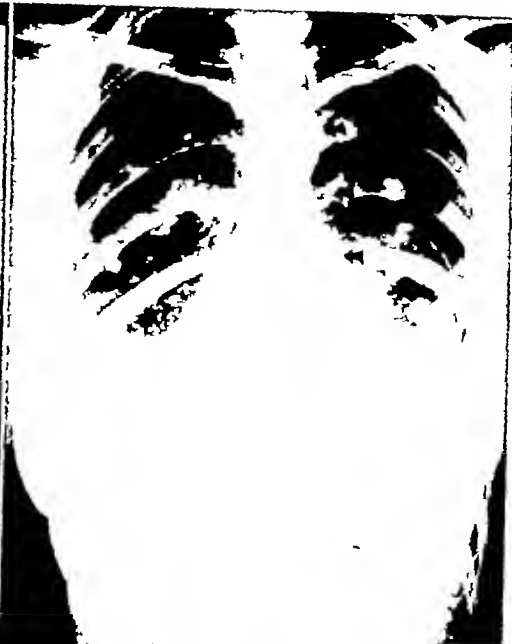


Fig 8

Fig 8 Expiratory phase same case



Fig 9 Expiratory phase of hernia through lower posterior "weak spot"

the air occurred, but a small pneumothorax remained. We now see (Fig 6) that the situation has changed and, instead of the former pulsion hernia, we have a traction hernia. The intrapleural pressure on the right at this time was -6-12 cm. of water. This case demonstrates that the process is reversible and that the direction of the herniation depends on the difference in the intrapleural pressure on the two sides of the mediastinum. The hernia always points toward the side with the lower pressure.

Figures 7 and 8 are from a case of bilateral pneumothorax in which there is a mediastinal hernia. The question arises here as to whether this is due to too much air on the right side or too little air on the left side. By studying these films, taken in inspiration and expiration, we see that the hernia is larger during inspiration and, therefore, we are dealing with a traction hernia from too little air on the left side. The intrapleural pressures confirm this, that on the right being -3-8 cm. of water and on the left -5-11 cm.

Subsequently, the pleural rent became sealed off and partial absorption of

He illustrates a case of a left mesial effusion with spontaneous rupture, showing a fluid level in the sac alongside and behind the heart shadow

It is evident from the above references that mesial empyema is often a clinical problem and sometimes presents considerable difficulty in diagnosis. It is often overlooked. It follows or is concurrent with lobar pneumonia, and usually presents the classical signs of pus.

The mediastinal dullness to percussion is widened if the effusion is large enough. X-ray examination is the greatest diagnostic aid. Beside films in the usual position, fluoroscopic examination, and films in lateral and oblique positions, may be of value. Occasionally the Bucky diaphragm technic may be used in an effort to differentiate various densities.

Mediastinal and bronchial tumors sometimes cast a shadow similar to mesial effusion, but the clinical history and course should suggest inflammatory lesions when present.

The proximity of these effusions to the heart may make them appear to be part of it and the distinction between them and a pericardial effusion may be impossible. The shadow of pericarditis is homogeneous, while often the adjoining effusion is of a different density and a double heart shadow is made out.

A tuberculous spinal abscess may cast a fusiform shadow behind or to the right of the heart, but examination of the vertebral shadows should show its true nature.

CASE REPORTS

The patient, J. M., a soldier, age 55, weight 160 pounds, became ill on July 28, with a chill followed by a temperature of 103 degrees Fahrenheit. He had severe pain in the right chest and blood-streaked sputum. He was admitted to the hospital on July 29. The pleural pain was so severe that morphine was required.

Physical examination revealed signs of pneumonic consolidation in the right lower lobe. Roentgen examination showed the

right diaphragm obscured by an irregular area of consolidation, with definite thickening of the pleura along the axillary border. The trachea was in the midline and the heart moderately large. The left lung was clear.

July 31 Blood and sputum cultures were positive for Type II pneumococcus, and 50,000 units of Felton's antipneumococcus serum, Types I and II, were given during 48 hours, with marked clinical improvement.

August 1 In spite of his good clinical condition, examination showed a large area of consolidation in the left lung, apparently an extension. His temperature went up to 104° F. A bedside film showed the trachea, heart, and mediastinum markedly displaced to the left. The intercostal spaces were retracted but the diaphragm was not elevated. The lung was opaque and the picture rather typical of massive atelectasis. The right base showed considerable resolution, and the diaphragm was no longer obscured.

August 6 The temperature dropped by lysis and reached normal. August 6. The patient's general condition was quite satisfactory. A film showed further clearing of the right lung. The left lung had the appearance of resolving pneumonia. The heart and mediastinum were still displaced to the left.

August 10 Though feeling quite well, the patient began to run daily evening temperatures of 100–101° F. A film showed the right lung clear, and the left lung showed further expansion and resolution, but the heart and mediastinum were definitely displaced to the left.

August 15 The evening temperature was running a little higher and the leukocyte count around 15,000. A film showed further clearing of the left lung, the heart much displaced to the left, the mediastinal shadow markedly widened on the right, suggesting encapsulated fluid.

August 21 The patient was feeling better and the general condition was good. Percussion dullness in the mid-chest extended 2.5 cm. to the right of the sternum.

TWO UNUSUAL CASES OF EMPYEMA WITH SPONTANEOUS DRAINAGE

By Lt Col ALBERT BOWEN, M C , Ft Sam Houston, Texas

ENCAPSULATED suppurative pleurisy presents many interesting diagnostic problems to both clinicians and radiographers. Two such cases have recently stimulated a study of this condition. One was mediastinal, the other interlobar. Both ruptured into a bronchus and both patients made excellent recoveries.



Fig 1 Mediastinal abscess following perforation of esophagus

Mediastinal empyema is in reality a suppurative pleurisy localized between the mediastinal and visceral layers of the pleura. It is also referred to as "mesial empyema." It may occur on either side of the mediastinum and is localized posteriorly more often than anteriorly. Wessler and Jaches (1), in their classic book, describe the condition as follows:

"A collection of fluid between the mediastinum and the lung is undoubtedly the rarest

of all effusions. Its development presupposes a fixation of the anterior or posterior margin of the lung, by which the fluid is retained in the mediastinal recess and is prevented from communicating with the general pleural cavity.

Owing to the limited respiratory movement of this part of the chest, adhesions often wall it off from the lateral half of the pleural cavity. A mesial empyema may be primary, in addition to a lateral empyema, or develop after a surgical drainage of an ordinary type, due to infection of a previously uninfected mesial area. The proximity of these effusions to the heart may make them appear to be a part of it and the distinction between them and a pericardial effusion may be impossible."

Suppurative mediastinitis, or true mediastinal abscess, is a more rare and usually a fatal complication of some surgical condition—as a penetrating wound or esophageal perforation. Such an abscess is shown in Figure 1. Wessler and Jaches (p 401) report a case of abscess in the right lower posterior mediastinum following lobar pneumonia which did not involve the pleura and which on the film could not be distinguished from a mesial effusion.

Snure (2) reviews the literature of mediastinal pleurisy and gives his findings in three cases. He says:

"While mediastinal pleurisy is not a frequent lesion, it is probably more often overlooked or incorrectly diagnosed than any other pleural condition. Unless an x-ray examination is made, it is not often diagnosed until rupture into a bronchus or other organ of the chest occurs. It would seem that pure pneumococcus type of effusion is about the only form that can rupture into a bronchus and the patient survive. Rupture usually takes place within a twenty-day period."

Sante (3) says:

"Effusions entrapped between the mediastinal pleura and the medial border of the lung are very rare, and we have never seen one which was localized close to this area that required operative procedure for evacuation."

showed little displacement. The rounded mass in the cardiohepatic angle was markedly decreased in size and the parenchymal perifocal reaction largely absorbed. On the lateral film the shadows behind the sternum had shrunk to an irregular narrow mass (Fig. 4).

November 9 The lungs were clear except for some residual thickening of trunks and pleura and the patient was clinically well.

Comment—The early displacement of the heart toward the left due to atelectasis of the left lung added to the difficulty of an early diagnosis of encapsulated fluid at the right of the heart. The mesial pleural area was probably walled off by the early pleurisy. At no time was the "double heart shadow" distinguished. Pericarditis with effusion was considered because of the tremendous apparent heart shadow. On the other hand, the danger of infecting the pericardium was a deterring factor in exploratory puncture. The excellent condition of the patient, together with absence of all pressure symptoms, led to postponement of surgical intervention, and while the surgeons delayed the patient very successfully drained himself spontaneously, on the thirty-ninth day after onset of the pneumonia. One wonders whether the large amount of anti-pneumococcus serum might not have been a factor in bolstering the patient's resistance to the large and prolonged empyema from which he suffered.

The second case is one of large interlobar effusion. In 1923 Wessler and Jaches (p. 352) said, "Interlobar effusions are as rare as they are difficult to diagnose by the usual clinical means." The progress in the study of this condition is well shown by Levitin and Brunn in a scholarly and exhaustive article in *RADIOLOGY*, December, 1935 (4).

Interlobar effusions and pus pockets are not uncommon and often are demonstrated on chest films as shadows of varying width along the interlobar lines. They are usually small and are easily



Fig. 4 Case 1. One month after rupture. Collapsed pus pocket retouched.

recognized in lateral films if not clearly demonstrated in the usual position. The shadows tend to remain central. Of large interlobar effusions, not much is reported. Wessler and Jaches (p. 362) show one case in which the effusion appears as a large cystic shadow obscuring nearly the whole lung but showing rounded margins and clear lung surrounding it.

Interlobar effusions are more common on the right side because there are more interlobar fissures and pneumonia is more commonly right-sided. Effusions in the horizontal fissure appear smaller than those in the oblique major fissure which is the interlobar fissure bordering the upper surface of the right lower lobe. In the postero-anterior view it presents a surface which is broad, extensive, and oval in shape. An effusion confined to this area can be mistaken for a large tumor. The lateral view usually establishes the position of this shadow within the interlobar fissure. The following case developed such an effusion and presented many difficulties in diagnosis.

Case 2. M. M., aged 8, on February 27



Fig 2 Case 1 Lateral film (retouched) showing extent of anterior mediastinal empyema



Fig 3 Case 1 Five days after rupture of mediastinal empyema Lower portion still very prominent

The veins on the chest were enlarged. Radioscopic examination showed a non-pulsating oval mass to the right of and not connected with the heart. Films showed considerable inflammatory reaction in the lung parenchyma at the periphery of the mass. The impression was mediastinal empyema.

August 27 The patient remained in good condition. A film showed the heart displaced to the left by a rounded mass extending from the right hilus to the diaphragm, which could not be distinguished from the heart shadow.

August 30 The patient appeared to be improving clinically, having no pain or difficulty in breathing. The percussion dullness was 11 cm to the left of the mid-sternum and 6 cm to the right. Roentgenological report: The mass is larger. Lateral film shows a hemielliptical shadow in the anterior mediastinum extending upward 15 cm from the diaphragm and 4.5 cm centrally behind the sternum. This overlies the anterior part of the heart

shadow. Impression: anterior mediastinal empyema (Fig 2).

September 4 Films showed an additional rounded shadow in the cardiohepatic angle.

September 5 At 5 P.M. the patient began to raise large quantities of foul sputum and filled six sputum cups during the night. The following day he raised only 60 c.c. He continued to show marked clinical improvement.

September 8 Films showed marked decrease in the size of the shadow at the right hilus with definite return of the heart toward the normal position. The lower rounded shadow near the diaphragm was more prominent. The patient showed exacerbations of fever from time to time coincident with his failure to evacuate the sputum from his cavity. This was definitely helped by postural drainage (Fig 3).

October 5 The mediastinal shadow was much smaller and in nearly normal position. The heart shadow was smaller and

Clinically the patient had been eating well and gaining weight and was with difficulty kept in bed. She did not complain and was not toxic. The day previous to the discovery of the air in the empyema pocket the patient began to expectorate pus, and it was very evident on viewing the film that the interlobar empyema had ruptured into a bronchus and was evacuating spontaneously. She spit up fairly large quantities of pus on three occasions, and gradually cleared the pocket, which was rather promptly obliterated by the expanding lung.

From the films it is evident that this was a very large interlobar effusion extending the whole length of the major fissure and compressing the surrounding lung. The early pleurisy had apparently sealed this fissure so that it did not communicate with the parietal pleural space. The long-continued obliteration of the entire lung was very puzzling. Over-exposed films failed to demonstrate any encapsulation

until after it had begun to empty. This case did not rupture spontaneously until 43 days after the beginning of the pneumonia.

These two cases seem to indicate that pneumococcic empyema encapsulated mesially or in the interlobar fissures may evacuate spontaneously without leaving bronchial fistulae, as is so often the case when parietal empyemas rupture into a bronchus. This may offer some comfort to the doctor vainly struggling to aspirate interlobar or mediastinal effusions.

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Fig 5 Case 2 Interlobar empyema soon after rupture showing air in upper part of pus pocket



Fig 6 Case 2 Lateral film showing interlobar empyema half drained

became acutely ill following a cold. On March 3, she was admitted to the hospital with symptoms of pneumonia and a temperature of 104°F . Her chief complaint was pain in the right chest and abdomen. Examination revealed typical sign of pneumonic consolidation in the right lower lobe. The organism typed in Group IV. Pain was marked for the first week. There was evidently pleural involvement from the onset.

Temperature began to drop on March 8 and fell below normal on March 10. Thereafter it was rather irregular, with evening rise and continued leukocytosis pointing to suppurative pleurisy. Repeated attempts to find fluid with an aspirating needle failed to locate it.

The first x-ray examination showed consolidation of the right lower lobe. On March 8, the entire right side was obscured and the mediastinum pushed to the left. The impression was that it was a case of pleural effusion. A week later there was

a thin line of translucent resolution above the right diaphragm, otherwise the whole right side was opaque. A film on March 24 showed marked dorsolumbar scoliosis which patient could not overcome. The right chest was still opaque and no encapsulated fluid was made out. On April 10 there was little change in the appearance of the chest except some retraction of the interspaces. Films (Fig 5) on April 14 showed more clearing above the right diaphragm and a translucent triangular area at the level of the clavicle which was believed to be due to air over fluid. Additional films were made in right and left lateral decubitus which demonstrated very definite fluid levels in an encapsulated area in the mid-lung. Lateral films (Fig 6) showed the pus pocket clearly, about half full of fluid. Both posterior and lateral films clearly showed this pocket completely surrounded by lung tissue and definitely located it as interlobar.

oblique views Ghormley and Kirklin (3), Hadley (4), and others have described the technic, and have demonstrated its worth.

In spite of this, I feel that some radiologists do not completely understand the anatomy of the spine as revealed in oblique roentgenograms, and therefore, have not used them to their fullest advantage.

Technic—The technic for getting satisfactory oblique views of the lumbar spine is not difficult, though sometimes, some ingenuity will be needed to properly show some of the smaller lumbar articulations.

The angle of obliquity of these joints varies from one to another, and between the various joints in the same spine, so that an exact angle to which the patient must be turned, such as advocated by Ghormley and Kirklin, does not seem to be feasible or necessary. For the same reason elaborate protractors or central ray directors are not needed.

The patient is placed on a flat Bucky table with his legs extended and is raised about forty-five degrees toward the side to be examined, that is, if the right facets are being examined, the left side is raised. The hand of the raised side grasps the edge of the table and thus steadies the upper part of the body, the lower part of the body is maintained in an oblique position by sandbags placed under the upper part of the thigh. The long axis of the spine is centered on the table and the central ray is directed to whatever region is being examined. The exposure will be about two and one-half times that given for the usual anteroposterior projection. A suggested setting would be 70 kv p, 30 in. distance, 50 ma, 8 seconds.

Stereoscopic roentgenograms in the oblique position furnish a splendid means of familiarizing the radiologist with the anatomy of the region, and are of great value in special cases. The shift should be in the long axis of the body.

Radiographic Anatomy—The radiographic anatomy of the region can be studied best by comparing the radiograph with the articulated spine. In the oblique view, the superior and inferior articular processes

should be well shown and the zygapophyseal joints definitely outlined. The ends of the articular processes are normally



Fig 2 Roentgenogram of the left zygapophyseal joints in a normal spine

smooth and round. Pointed or irregular ends indicate pathology. The joint space is normally about a millimeter in width. The joint surfaces are smooth and should be parallel when the patient is in the straight position, but when the back is bent to either side the spaces become wedge-shaped (Fig 1).

Chandler (2) has pointed out the very great importance of the region known as the "pars interarticularis," or, as he aptly calls it, "the isthmus." This area is that part of the posterior arch where the lamina and inferior articular process join the heavy bony mass made up of the bases of the pedicle, transverse process, and superior anterior process. It is apparently a rather vulnerable region and one that can be adequately visualized only in the oblique position (Fig 2).

THE VALUE OF THE OBLIQUE VIEW IN THE RADIOGRAPHIC EXAMINATION OF THE LUMBAR SPINE

By S A MORTON, M D, *Milwaukee, Wis*

From the Department of Radiology, Marquette University and from Columbia Hospital

THE extreme importance of the radiograph in the study of anatomy and physiology of the spine is generally recognized. The information that has been acquired by the radiological study of the spine has been gained largely from the study of the routine anteroposterior and

of structure, there are parts of the spine that are not adequately visualized by the conventional plates and, in order that all parts of the spine may be seen, oblique plates are often necessary.

One finds reference to the oblique projection of the spine in European literature

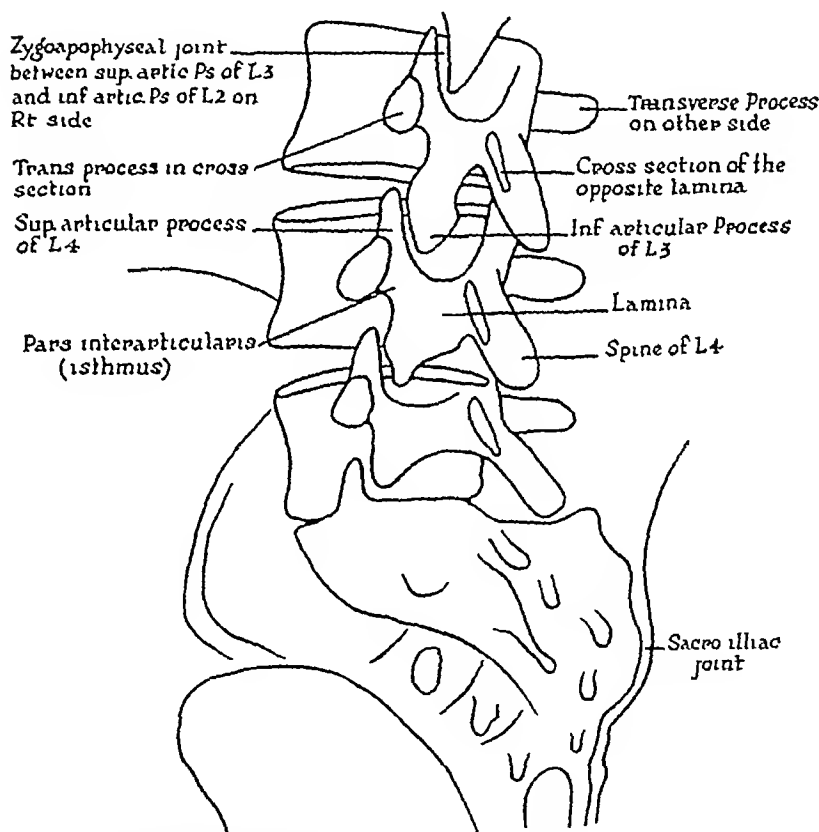


Fig 1 Diagram of a roentgenogram of the spine showing in particular the right zygapophysial joints with related structures

lateral roentgenograms of this region. Each individual vertebra is a complex bony structure and when it unites with the other vertebrae above and below it to form the spinal column, a still more complex arrangement results. Due to this complexity

under the name of the "Dittmar Position". The work of Meyer-Burgdorff (7) and Lange (6) did much to demonstrate the value of this position.

In this country, Hubeny (5) was perhaps the first to call attention to the value of

individual, the lateral margin of the lamina, the external aspect of the superior articular process, and the lateral border of the

lamina. No constant distance was noted, there being considerable variation in these distances from one spine to another. Sev-



Fig 5 A roentgenogram of a case with an interarticular defect.

pedicle form an S-shaped curve. A break in this curve is suggestive of a subluxation and should be confirmed by an oblique view (Fig 6).

In the oblique view one can see the degree of subluxation and can sometimes demonstrate actual impingement of the upper end of a superior articular process with the lower margin of the pedicle above, or of the lower end of the inferior articular process with the upper margin of the lamina below (Fig 7). In this connection, measurements were taken in a series of normal spines to determine whether or not there was any constant distance between the tip of the superior articular process and the lower margins of the pedicles and the base of the transverse processes or between the lowermost portion of the inferior articular process and the upper border of the

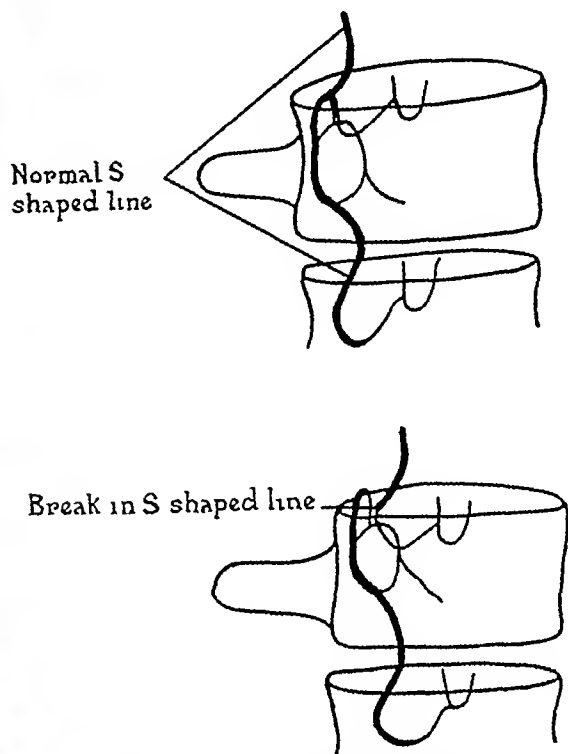


Fig 6 Diagram to show the normal S-shaped line made up of lateral margins of lamina, superior articular process, and pedicle.

eral points, however, were noted on measuring these distances. They are greater in the upper and middle parts of the lumbar

TABLE I—DISTANCE FROM THE SUPERIOR ARTICULAR PROCESS TO THE LOWER MARGIN OF THE PEDICLE AND TRANSVERSE PROCESS ABOVE

Vertebra	2	3	4	5
Distance in millimeters	15	14	9	5

TABLE II—DISTANCE FROM INFERIOR ARTICULAR PROCESS TO THE SUPERIOR BORDER OF THE LAMINA BELOW

Vertebra	2	3	4	5
Distance in millimeters	7	6.5	4.5	4

Chamberlain (1) has emphasized the fact that in the oblique radiograph, as one descends, each zygapophyseal joint is break in continuity can be demonstrated and, also, the loss of the normal relation between the adjacent zygapophyseal joints

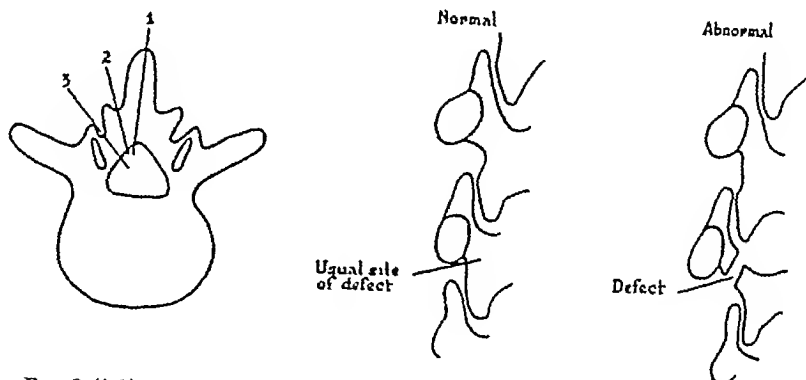


Fig 3 (left) Diagram showing the locations of separations in the neural arch (1) defect in the spinous process (2) defect in the lamina, (3) defect in the interarticular portion (Adapted from Willis)

Fig 4 (right) Diagram to show site of defect in spondylolisthesis. Note defect in the isthmus and the loss of normal relation of the zygapophyseal joints—the lower one on the abnormal side appears posterior

situated slightly more anterior than the one above it. If this relation is not present, some pathologic processes causing the displacement should be considered.

There is normally considerable variation in the appearance of the spine in the oblique view so that one must not regard as pathologic every slight variation from the textbook normal.

The most important lesions occurring in the lumbar spine in which the oblique view gives valuable information will be discussed.

Separations in the neural arch of the last lumbar vertebra are quite common. These may be bilateral or unilateral and may occur in various regions of the arch. Defects in the arch posterior to its interarticular portion are common and are not usually the cause of symptoms. The familiar spina bifida occulta is an example of this type. Interarticular defects are not so often seen in the routine anteroposterior roentgenograms (Fig 3).

The demonstration of the presence or absence of a separation in the neural arch is very important in the diagnosis of spondylolisthesis; this can best be done by an oblique ray. In this view the actual

is seen. True lateral roentgenograms will also show the lesion in the isthmus, but the oblique views will tell whether it is unilateral or bilateral and just where it is located (Fig 4).

In some cases it is exceedingly difficult, particularly in the light of the admittedly debatable etiology, to decide how much of the factor an alleged trauma was in the production of this lesion. In such cases stereoscopic oblique roentgenograms are particularly helpful, showing one if any comminution, callus, or other structure is present that might suggest a recent traumatic fracture. I have been impressed in many cases by the smoothness of the "fracture" line (Fig 5). Willis (8), whose work on anatomic variation at the lumbosacral junction is outstanding, feels that these are not actual fractures of the bone but rather "actual disunion, the result of trauma to a pre-existing defect so that fibrous or cartilaginous tissue is fractured." However, I believe that actual bony fractures can occur in this region, the result of severe trauma.

Subluxations of the zygapophyseal joints as described by Hadley, are seen quite often in the anteroposterior

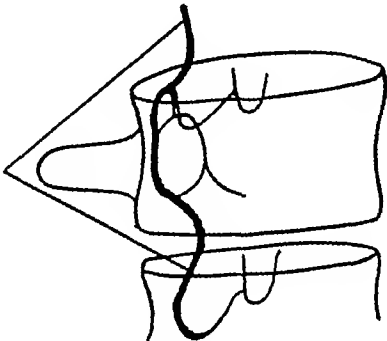
individual, the lateral margin of the lamina, the external aspect of the superior articular process, and the lateral border of the

lamina. No constant distance was noted, there being considerable variation in these distances from one spine to another. Sev-



Fig 5 A roentgenogram of a case with an interarticular defect.

Normal S shaped line



Break in S shaped line

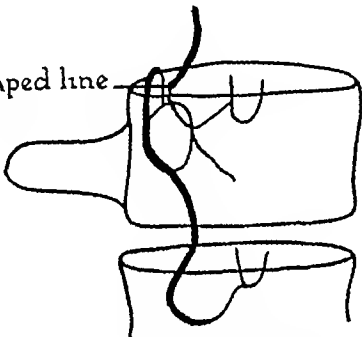


Fig 6 Diagram to show the normal S-shaped line made up of lateral margins of lamina, superior articular process, and pedicle

pedicle form an S-shaped curve. A break in this curve is suggestive of a subluxation and should be confirmed by an oblique view (Fig 6).

eral points, however, were noted on measuring these distances. They are greater in the upper and middle parts of the lumbar

In the oblique view one can see the degree of subluxation and can sometimes demonstrate actual impingement of the upper end of a superior articular process with the lower margin of the pedicle above, or of the lower end of the inferior articular process with the upper margin of the lamina below (Fig 7). In this connection, measurements were taken in a series of normal spines to determine whether or not there was any constant distance between the tip of the superior articular process and the lower margins of the pedicles and the base of the transverse processes or between the lowermost portion of the inferior articular process and the upper border of the

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Vertebra	2	3	4	5
Distance in millimeters	7	6 5	4 5	4

spine than they are in the lower Also, the amount of clearance above the superior articular process is more than that

joint surfaces, and by diminution of the joint spaces. The ends of the articular processes are often rough and pointed and

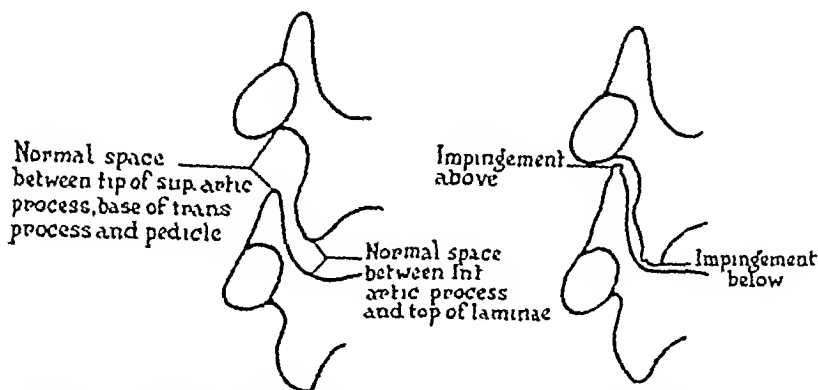


Fig 7 Diagram to demonstrate the appearance of a partial dislocation with associated hypertrophic changes

below the inferior articular process (Tables I and II)

If the fifth lumbar lies deep on the sacrum, the distances previously mentioned are less in the lower part of the spine than if it is a high-lying fifth lumbar. The importance of this point is that one should not diagnose impingements or near-impingements in the lower spine without very good evidence, because here the distance between the tips of the articular processes and structures with which they might impinge is less than in other areas of the spine.

Sometimes in a severe injury to the spine, with a compression fracture of the vertebral body, there is an actual dislocation at the zygapophyseal joints. The superior processes get behind the inferior instead of in front, which is the normal relation. This is rather obvious and is particularly well shown when viewed obliquely.

Arthritic changes in the zygapophyseal occur and apparently are the cause of considerable pain in the lower back, though in the examination of the gastro-intestinal tract and kidney, it is not infrequent to observe rather marked changes about these joints. In many of these patients, it is impossible to elicit any history of pain in the back. Arthritic changes are manifest by a loss of the usual smooth margins of the

areas of bone sclerosis are noted about the affected joints.

In that group of cases which go by the names of arthritis deformans, spondylosis rhizomelic, spondylosis ankylopoietica, Marie-Strumpell, and Bechterew's diseases, the oblique projection aids greatly in seeing the nature of the lesion. Destructive changes in the zygapophyseal areas are seen and an ossification of the ligaments about these joints is observed.

The importance of the roentgenogram in the diagnosis of intraspinal tumors is now well known. In most cases the most essential information is obtained on the anteroposterior and lateral examinations, but often additional information can be gained in the oblique projection, particularly in estimating the amount of bony destruction.

Various anomalies of the lumbar spine such as accessory ossicles about the articular processes or abnormal arrangements at the lumbosacral joint are sometimes seen to better advantage in the three-quarters view.

It is often possible to get a view straight through at least the upper part of a sacroiliac joint in this position, which may be of value in certain conditions of sacroiliac disease.

Thus it can be seen that the oblique view

gives added information in various types of spinal conditions. It is not advocated that this position be used routinely, but it should be employed in all cases of spondylolisthesis and in selected cases of obscure back pain. Stereoscopic views in this position are also of great value in teaching, because they give a picture of the anatomy of the spine entirely different from the routine anteroposterior view.

SUMMARY

In order to properly visualize certain areas of the lumbar spine, oblique roentgenograms are necessary. The technic of obtaining this view is described and the normal anatomy, as revealed in the roentgenogram, is discussed. The zygapophyseal joints are best studied in this position. The various lesions occurring in or about them in which the oblique view is particularly valuable are described.

3321 North Maryland Ave

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RADIATION PROCTITIS

A PRELIMINARY REPORT OF 39 CASES¹

By HARRY E. BACON, M.D., F.A.C.S., Philadelphia

ALTHOUGH possibly of a lesser import, one of the fascinating aspects of coloproctology is the occurrence of various processes, extrinsic and remote, which manifest themselves in the rectum or influence its general state. Among these are such conditions as endometriosis, Krukenberg tumor, certain vestigial remnants forming presacral tumors and cysts, metastatic growths in the cul-de-sac from various organs, and radiation proctitis. This latter is encountered with sufficient frequency to warrant consideration, especially since radiation in the treatment of cervical and fundal cancer is advocated by the leading gynecologists in this country and abroad, who feel it to be the method *par excellence*.

As is known, radiation gives rise to congestion and obliteration of the blood vessels. That there is brought about cessation of mitoses and cell division, with subsequent disintegration and absorption of these cells, has been shown. To evaluate better the effect on the rectum, we must appreciate the fact that this regression is followed by fibrosis or connective tissue replacement, which in itself retards cell proliferation.

The effects of radium and the roentgen ray on the rectum were described by Futh in 1915 (3), mentioned by Weishaupt in 1918 (4), and discussed at length by Buie and Malmgren in 1930 (2). By the last two authors this condition is termed "factual proctitis."

Radiation proctitis represents an inflammatory process of the rectum resulting from the use of x-ray and radium, usually in the treatment of extrarectal malignant growths, predominantly uterine, however, other instances have been noted. Appar-

ently radium is the causative factor, in no instance have we observed a similar proctitis following the use of roentgen therapy alone. It has been reported, however, by others, in cases receiving very large total doses of daily fractionated x-ray, after the method of Coutard.

The purpose of this paper is to present data and the findings in 39 cases in which radium, alone or in conjunction with roentgen rays, was employed outside the rectum. Radiation proctitis resulting from the intrarectal use of radium is omitted from this discussion. This series has been collected over a period of time, and each case has been seen personally by the author, either in private practice or in the Temple, Graduate, or Philadelphia General Hospitals.

All the patients were females between the ages of 27 and 69. Four of the most severe cases were in women in their early thirties, three of whom were colored. It is of interest to mention that six patients were exceptionally obese. The entire group were being treated for malignancy of the cervix or body of the uterus, except one, who had a myofibroma. Interstitial intracervical, or intra-uterine radiation was given in the order of frequency. In many, no estimate of the dosage was obtainable. Brust (1) believes that the total number of milligram-hours of radium applied does not seem to bear a direct relationship to the occurrence of proctitis. Buie and Malmgren state that in their series the smallest dose was 800 and the largest 15,100 milligram-hours, with an average of 5,856. So far as we could determine from patients and their records, 12 received no roentgen therapy. It seems only proper to report that the majority of cases, 74 per cent to be exact, received their treatment in hospitals other than those cited above.

¹ Read before the Proctologic Society of the Graduate Hospital Dec 15 1936

The pathologic changes may be grouped in three stages. The first, congestion or hyperemia, is noted in the early or incipient cases. The process is observed first on the anterior rectal wall. In 65 cases, Buie saw one with the lesion entirely on the right wall, three, on the anterior right wall, and one, lateral and posterior. The author has observed that the lesion usually begins on the anterior wall but is by no means confined to it, at times, the rectum may even be encircled. The process begins approximately from three-quarters of an inch to an inch above the anorectal line, to extend upward for a distance of from one-half to one inch. Examination elicits usually a circumscribed area of thickening not unlike a few layers of thin, wet cardboard in the anterior rectal wall. The mucosa is non-adherent, reddened, edematous, and covered to a slight degree by a non-characteristic mucoid exudate.

The second, or ulcerative, stage is usually quite characteristic as far as the findings are concerned. Here the thickening is more marked, with extension laterally rather than longitudinally. The mucosa seems quite adherent to the deeper layers, a distinct change from the initial stage. Situated on the anterior rectal wall or at times slightly to one side there is a horizontally oval, irregularly rounded ulceration from one-half to one and one-half inches in extent. It occurs as a pearly-white or grayish plaque, giving the impression of being plastered on the surface, but close inspection reveals it to be a necrosis of the mucosa and often the submucosa. Often a dirty-sticky material is present over the surface of the membrane, but this can be swabbed away easily, leaving a clear membrane as above described. The center appears slightly elevated and the edges are somewhat depressed, forming a prominent gutter with the surrounding mucosa. This membrane is quite adherent and tough, so that if it is pulled away a deep ulcer remains which bleeds considerably. After a period of from ten to fourteen days the center is more loose and the edges are elevated and still later the necrotic membrane

begins to slough away. Two cases in this series developed a rectovaginal fistula, which opened exactly in the center of the



Fig 1 Radiation proctitis showing pearly-white plaque on the anterior wall of the rectum. The elevated borders and telangiectasis may be seen. Case of squamous-cell carcinoma of the cervix, Type 4. Patient had received approximately 11,000 mc-hr intracervically and intravaginally.

ulcer. The mucosa immediately adjacent is more or less atrophic and pale, so that the small blood vessels are unduly prominent. This telangiectasis, according to Buie, is pathognomonic.

In the third stage, where a stricture has formed, there is an organized narrowing of the rectal lumen approximately from three-quarters of an inch to an inch and one-half above the anorectal line. It is usually annular, and may be partial or complete, but is devoid of the nodular excrescences usually palpated in primary or extended malignancy. Ulceration is frequent but, because of secondary infection and the progress of the disease, is not characteristic.

In almost every instance the patient will mention that some form of vaginal treatment has been given previously but that now the complaint is rectal. Bleeding is invariably the most common symptom, usually associated with defecation. It may be bright red drops, dark clots, or streaks on the stool. Rarely a profuse hemorrhage is cited. The initial discom-

fort is indefinitely described as a dull, aching sensation, occasionally, however, the pain is of a burning nature. Later, tenes-



Fig 2 Radiation proctitis showing similar plaque on the antero-lateral wall of the rectum. Telangiectasis is well shown. Squamous-cell carcinoma of the cervix. Grade 2. Patient had received 9 000 mc-lir of radium.

mus of varying intensity occurs, the result of sphincteric irritability from the inflammatory process. Such symptoms as frequent and urgent desire for stool, incomplete evacuations, fecal discharges mixed with mucus, pus, blood, and necrotic material are cited in cases in which a stricture is present.

With a history of interstitial uterine radiation and the presence of a pearly-white plaque situated on the anterior rectal wall, there is little difficulty in making a diagnosis of radiation proctitis. However, this process not uncommonly encircles the rectum, in which case it is often no easy matter to decide whether it is the result of radiotherapy or an extension of the malignancy. Of course, the history is of value but does not rule out the possibility of extension. In cases in which malignancy has extended to the rectum there is no typical membrane, and the constriction is irregular and nodular in contrast to the more even distribution of the fibrosis resulting from radiation. Repeated negative biopsies from different portions of the stricture are

the only absolute means of ruling out malignancy.

In first-stage cases the prognosis depends upon the behavior of the growth for which radiation treatment was originally given. If this responds favorably, the rectal complication is relieved, although in Bue's experience there is always some bleeding. The ulcerative group, especially if fistula occurs, has a very problematic prognosis. We say this because a few of the cases in which the primary growth was thought to be controlled failed to respond to proper and regular treatment of the rectal condition. In cases in which stricture is present, of course, the prognosis assumes the doubtful aura that always surrounds this syndrome.

In the first and second stages palliative treatment is usually all that is required, but stricture, as a rule, necessitates surgical intervention. The palliative measures employed are rest in bed, a soft, bland diet, and liquid petrolatum by mouth. Absolute cleanliness will do much in itself to aid healing, and to this end an irrigation of warm potassium permanganate solution, 1:10,000, after each defecation, is helpful. Compresses wrung out in hot boric acid solution and applied to the perineum, and hot sitz baths offer temporary relief. Instillations of warm olive oil, two ounces thrice daily, are soothing and will relieve the tenesmus. Ichthyol, 25 per cent aqueous solution, and hamamelis water lessen inflammation and promote healing, while gentian violet, 1 per cent solution, or balsam of Peru, applied to the ulcerated surface every second day, is also beneficial. Severely painful cases may require surgical intervention, especially if stricture is present. Fourteen patients in the author's series presented stricture of the rectum. In eight of the 14 cases the symptoms were so distressing and the process was so extensive that colostomy was performed. In two of these eight, stricturotomy was first performed, but with only moderate relief. The simplest procedure is to divide the stricture longitudinally in its posterior phase with a cautery and sever the super-

ficial fibers of the external sphincter muscles (posterior sphincterotomy) Good results will be encountered temporarily, but subsequent contraction is to be expected. It would seem, therefore, that except in very early cases, colostomy is the procedure of choice.

SUMMARY

The rectal manifestations following the intravaginal and intracervical use of ra-

dium in 39 cases have been described and an attempt made to classify simply the various stages encountered.

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SIMULTANEOUS LYMPHOSARCOMATOSIS AND CARCINOMA OF THE BREAST IN THE SAME INDIVIDUAL

CASE REPORT

By HERBERT A. JUDSON, M.D., Los Angeles, Calif

INSTANCES of the occurrence of two entirely different types of neoplasm in the same patient at the same time have come within the experience of all radiologists. However, each such occurrence



Fig 1 Photomicrograph of the section from the breast tumor carcinoma simplex type. There are masses and columns of epithelial cells invading a more or less dense stroma. No definite lumen is seen in the masses. The cells are irregular in size and shape, many with hyperchromatic nuclei; an occasional mitotic figure is seen. In some of the groups the cells are very large, with clear cytoplasm and small nuclei ($\times 125$).

has peculiar aspects that make its study of value. The following case presents a number of interesting features and will, therefore, be reported in some detail.

CASE REPORT

K. B., female, single, 62 years of age when first seen, Dec 27, 1932. She came because of enlarged glands in the neck and axilla and a mass in the breast.

Family History—Her mother died of cancer of the liver, and one sister had cancer of the breast.

Personal History—Irrelevant as far as the present report is concerned.

Present Illness—About one month before entrance, the patient noticed a hard mass in the left axilla, and more recently a lump in the left breast. Several small glands were also felt along the left side of the neck. There had been a feeling of malaise and weakness gradually coming on during the past few weeks. She had lost 15 pounds during the past year.

Physical Examination—A hard mass was present in the left breast below the nipple, about 4×5 cm in diameter. There was dimpling of the skin over the mass, and the nipple was retracted. There was a gland the size of a small hen-egg in the left axilla. Numerous small lymphatic glands were present in the left cervical region. Examination otherwise was essentially negative.

Laboratory Findings—Blood: hemoglobin 84 per cent, red cells normal, leukocytes total count 9,000, lymphocytes 25 per cent, large mononuclears and transitionals 5 per cent, polynuclears 70 per cent, platelets normal. Urine normal.

Diagnosis—Cancer of the left breast with axillary metastases.

Operation—A radical amputation of the left breast was performed Feb., 20, 1933, by Dr. Donald Ross. The microscopic diagnosis was adenocarcinoma of the breast (Fig 1), benign lymphoma of the axillary lymphatic glands (Fig 2).

Subsequent History—The patient made an uneventful post-operative recovery followed by roentgen therapy to the left breast area six weeks after operation. The small glands in the neck receded. In August, 1933, a large gland appeared in the left submaxillary area, which receded promptly with two x-ray treatments.

This recurred and was present when the patient was next seen in May, 1934. The cervical glands were also again enlarged

part of 1936, the patient developed pleurisy. Death occurred Feb 20, 1937. An autopsy, performed by Dr Leo Levi,

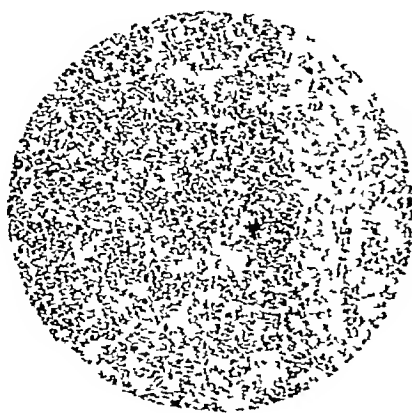


Fig 2-A

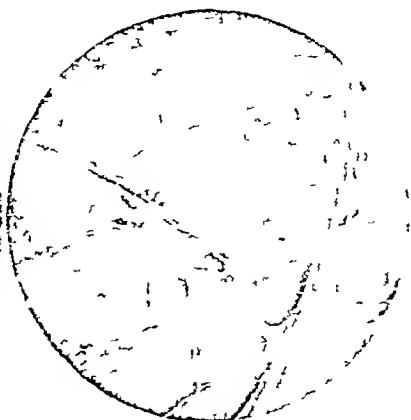


Fig 2-B

Fig 2-A Section from the axillary glands thought to be metastatic carcinoma of the breast but shown upon microscopic examination to be lymphoma. There are masses of closely packed lymphoid cells regular in size and shape. Occasional mitotic figures and hyperchromatic nuclei are present. No germinal centers are seen. No definite evidence in this section of infiltrating lymphosarcoma ($\times 125$).

Fig 2-B Low power view of the section from the axillary glands. The normal structure of the glands is preserved and there is little to suggest the widespread invasive lymphosarcomatosis that is to ensue ($\times 10$).

In October, 1934, a peculiar throat condition appeared, with marked enlargement of both tonsils, portions of which hung down into the throat in pedunculated masses. A biopsy specimen of the right tonsil showed lymphosarcoma (Fig 3). Roentgen therapy was instituted on Nov 13, 1934, by Dr Seeley G Mudd at the California Institute of Technology. Between that date and Dec 26, 1936, the patient received 34,924 roentgens. This dosage was divided into eight cycles, being directed to several areas (spleen, epipharynx, larynx, chest, anterior left and right thighs, left shoulder, right knee, right lateral forehead), since during the interim in which she was under observation masses became apparent in these several regions. The masses showed uniformly rapid response to comparatively moderate dosage of external radiation.

Of particular interest was the involvement of the stomach and duodenum, manifesting itself by epigastric distress in March 1936 (Fig 4). During the latter

showed a well-healed scar over the left chest of a radical mastectomy. No macroscopic evidence of carcinoma was seen. Masses were noted in both groins, in the mid-portion of the right arm, and numerous shot-like nodules were encountered in the subcutaneous tissue. They were firm in consistency, the cut surface having a homogeneous, firm, white appearance. Bilateral pleural effusion was present, the left lung showing a collar of white tissue about the terminations of the bronchi. The stomach and small bowel showed nothing of interest. About 10 cm below the ileocecal valve, the descending and transverse colon showed pedunculated masses, which on cut section seemed to be composed of homogeneous, ivory-colored firm material. Similar white, firm, oval masses were seen shining through the capsule of the right kidney, and were found in the spleen, in the lesser omentum, and at the bifurcation of the iliacs.

Diagnosis—Generalized lymphosarcomatosis.

SIMULTANEOUS LYMPHOSARCOMATOSIS AND CARCINOMA OF THE BREAST IN THE SAME INDIVIDUAL

CASE REPORT

By HERBERT A. JUDSON, M.D., Los Angeles, Calif

INSTANCES of the occurrence of two entirely different types of neoplasm in the same patient at the same time have come within the experience of all radiologists. However, each such occurrence



Fig 1 Photomicrograph of the section from the breast tumor, carcinoma, simplex type. There are masses and columns of epithelial cells invading a more or less dense stroma. No definite lumen is seen in the masses. The cells are irregular in size and shape, many with hyperchromatic nuclei, an occasional mitotic figure is seen. In some of the groups the cells are very large with clear cytoplasm and small nuclei ($\times 125$).

has peculiar aspects that make its study of value. The following case presents a number of interesting features and will, therefore, be reported in some detail.

CASE REPORT

K. B., female, single, 62 years of age when first seen, Dec 27, 1932. She came because of enlarged glands in the neck and axilla and a mass in the breast.

Family History—Her mother died of cancer of the liver, and one sister had cancer of the breast.

Personal History—Irrelevant as far as the present report is concerned.

Present Illness—About one month before entrance, the patient noticed a hard mass in the left axilla, and more recently a lump in the left breast. Several small glands were also felt along the left side of the neck. There had been a feeling of malaise and weakness gradually coming on during the past few weeks. She had lost 15 pounds during the past year.

Physical Examination—A hard mass was present in the left breast below the nipple, about 4×5 cm in diameter. There was dimpling of the skin over the mass, and the nipple was retracted. There was a gland the size of a small hen-egg in the left axilla. Numerous small lymphatic glands were present in the left cervical region. Examination otherwise was essentially negative.

Laboratory Findings—Blood: hemoglobin 84 per cent, red cells normal, leukocytes total count 9,000, lymphocytes 25 per cent, large mononuclears and transitionals 5 per cent, polynuclears 70 per cent, platelets normal. Urine normal.

Diagnosis—Cancer of the left breast with axillary metastases.

Operation—A radical amputation of the left breast was performed Feb., 20, 1933, by Dr. Donald Ross. The microscopic diagnosis was adenocarcinoma of the breast (Fig 1), benign lymphoma of the axillary lymphatic glands (Fig 2).

Subsequent History—The patient made an uneventful post-operative recovery followed by roentgen therapy to the left breast area six weeks after operation. The small glands in the neck receded. In August, 1933, a large gland appeared in the left submaxillary area, which receded promptly with two x-ray treatments.

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Fig 1 Photomicrograph of the section from the breast (tumor, carcinoma simplex type). There are masses and columns of epithelial cells invading a more or less dense stroma. No definite lumen is seen in the masses. The cells are irregular in size and shape, many with hyperchromatic nuclei; an occasional mitotic figure is seen. In some of the groups the cells are very large with clear cytoplasm and small nuclei ($\times 125$).

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spread as to make the case seem hopeless, considerable palliation can be expected. Thus in the present instance the patient was kept in comparatively good health for about four years and continued with her work until within a few months of her death, this in spite of the fact that as long as two years before death the disease had invaded at least twelve known cutaneous and subcutaneous groups of glands, beside the deeper areas, the exact number of which could not be ascertained. At autopsy many of the involved areas showed regression and some formerly known to be affected appeared to be free from disease following radiation.

The roentgen examination of the stomach in this case illustrates some of the diagnostic points that have been used in differentiating gastric lymphoblastoma from carcinoma. Upon fluoroscopic examination the lesions were found to be soft, without palpable tumor mass, and not easily discernible. In spite of the thickening and distortion of the rugæ, there was little, if any, interference with peristalsis. This persistence of peristalsis in the face of a definite lesion was mentioned by Holmes (2) as being suspicious of lymphoblastoma, and this finding has been corroborated by Ruggles and Stone (3). The present case also shows definite infiltration of the duodenal cap. Martin (4) has more recently emphasized the diagnostic importance of finding an involvement of the duodenum in conjunction with a prepyloric lesion. Gastric carcinoma rarely infiltrates beyond the pylorus, whereas lymphoblastoma definitely has this tendency. Since, as Carter (5) has shown malignant lymphoblas-

toma will include more than half of the non-carcinomatous malignant tumors of the stomach, it is particularly important that there be some means of differentiation. These two points—relative lack of impairment of peristalsis in the presence of a gastric lesion, and involvement of both stomach and duodenum—may be of real value when present.

SUMMARY

A case of simultaneous occurrence of lymphosarcomatosis and carcinoma of the breast is presented. Attention is called to the insidious onset of the lymph gland involvement, to the marked regression of multiple lesions with roentgen therapy, and to the possible advisability of early systemic roentgen treatment. The differential diagnosis of lymphoblastoma and carcinoma of the stomach from the roentgen standpoint is discussed.

I wish to thank Dr Seeley G. Mudd and Dr Leo Levi for their courtesy in supplying many of the data used in this report.

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DISCUSSION

The appearance of two totally different biological types of neoplasms in the same

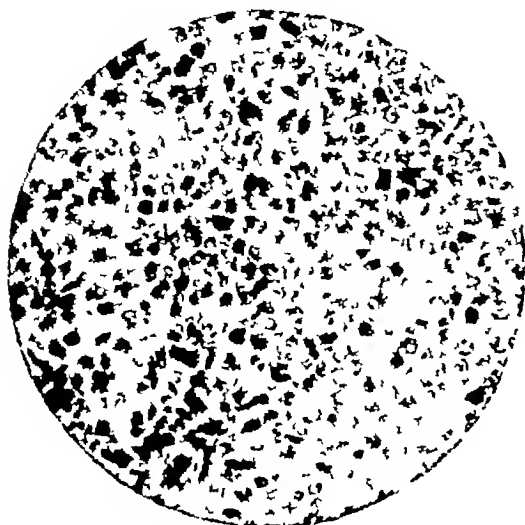


Fig 3 Section from tonsillar tissue removed by biopsy one and one half years following the mastectomy, lymphosarcoma lymphocytic type. The cells are fairly regular in size and shape, but with vesicular nuclei. Numerous mitotic figures and a few hyperchromatic nuclei are seen ($\times 480$)

individual at the same time is not a common finding. It is probably simply a matter of coincidence, and as such is of infrequent occurrence. To enter into any discussion of possible causative relationship is of academic interest only, for there is no reason why a person suffering from one type of neoplasm should not develop another, but this simultaneous occurrence does complicate the problems of diagnosis and treatment. It emphasizes the need to bear in mind that double neoplasms do occur and, although uncommon, need to be watched for.

The present case also illustrates the often insidious onset of the lymphoblastoma group. The presence of a second neoplasm was not suspected when the radical mastectomy was performed. The appearance of the axillary glands, while perhaps suspicious of early malignant changes, was more that of benign lymphoma. There was little indication of the generalized lymphosarcomatosis which

was to follow, involving at one time or another most of the lymph gland-bearing areas of the body, and of which the axillary gland involvement was undoubtedly the apparently innocent forerunner. It was not until later when the tonsils became affected that the malignant changes were unmistakable.

This insidious onset, with its tendency to wider spread, raises the question whether upon finding evidence of malignant change at one point in the lymphatic system it might be advisable to give prophylactic roentgen therapy to all the lymph gland areas, even to those not as yet openly involved. Experience seems to teach that only infrequently does the disease remain limited to a local area or single organ, and that many cases thought to be localized will later manifest the disease in other areas. Jacob's (1) comparative statistics indicate that systemic irradiation of all lymphoid areas brings better symptomatic response than the more common custom of treating local areas as they become manifestly involved.

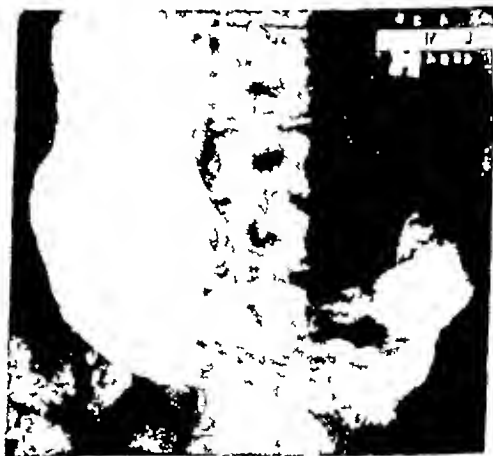


Fig 4 Lymphosarcoma of the stomach with soft lesions of the rugose polypoid type. There was little interference with peristalsis. Note the coincident involvement of the duodenal cap.

With either method the response to moderate doses of external radiation is prompt and marked relief may be obtained for a long period of time. Even in cases in which the disease has become so wide-



Figs 1 A and 1 B Illustrating the difference in density between regular film produced without intensifying screen and the new Agfa non-screen film—exposed simultaneously in the same cardboard holder

screen film adaptable to a Potter-Bucky diaphragm procedure, members of the General Electric X-ray Corporation's Technical Service Department began to investigate the possibilities

The results subsequently produced with the Bucky diaphragm, even on areas as thin as a hand and up to the thickness of the average shoulder, were startling. Introduction of the Potter-Bucky diaphragm into this procedure indicated that a new and considerably higher baseline for diagnostic roentgenography was not only possible, but also practical, for virtually all extremity work up to and including the shoulder.

When the Potter-Bucky diaphragm was employed, non-screen film made possible practically any desired degree of contrast, and furthermore, this contrast could be retained even though comparatively high kvp values were used. This gave the roentgenograms an appearance of transparency not obtainable by any other known

means. The unusual latitude made possible with the Potter-Bucky procedure enabled us to produce seemingly impossible results with areas of widely different opacities. In roentgenograms of a lateral knee, for example, taken at voltages sufficiently high to completely penetrate the lower extremity of the femur, no portion of the patella was obliterated. In fact, the radiographic density through the region of the patella was only slightly greater than the density through the much heavier part of the knee. Despite the high voltage value employed, the highest degree of detail visibility, in the form of contrast, was retained. It was found that variations as high as five or six kilovolts, either way from a given setting, made comparatively little difference in the quality of the end-result.

Thus it was apparent that a new and valuable procedure, of great assistance to the radiologist in the diagnosis of minute lesions, could be established with the non-

NON-SCREEN PROCEDURE WITH THE POTTER-BUCKY DIAPHRAGM

PRELIMINARY REPORT

By GLENN W FILES, *Chicago*

DURING the last few years changes have been made in x-ray film to make it increasingly selective to the longer wave lengths emitted by intensifying screens. Obviously, these changes in emulsion have contributed materially to the increase in so-called speed of film with which intensifying screens are employed.

The actual speed of regular x-ray film emulsions, when used without intensifying screens, has changed but little during the past ten years.

The character of regular x-ray film emulsion has also been changed, to provide increased contrast. In fact, up to two or three years ago there appeared to be a strong rivalry to see who could put the most contrast in the finished roentgenogram. However, this increased contrast in present day radiographs is available only when regular x-ray film is used in combination with intensifying screens.

It is generally recognized that radiographs made without intensifying screens show a marked increase in sharpness of detail or definition. Because of this increase in sharpness of detail, a non-screen procedure has been utilized for the lighter extremities for many years. However, non-screen procedure, as we have considered it in the past, could not be extended to heavier parts of the body, because the relatively low speed of the film has made necessary such high energy values for the heavier or more opaque parts of the body.

The advent of the rotating-anode tube, with its extremely small effective focal spots, served to accentuate the fact that while contrast is an important factor, detail sharpness or definition is, after all, of first importance. To the demands of the radiologist for increased detail sharpness, screen manufacturers responded with detail screens, which, although somewhat

slower than Hi-Speed screens, make possible sharper definition.

Despite the improvement in detail sharpness brought about through the use of finer grained intensifying screens, roentgenograms made without screens were still far superior in respect to actual sharpness of detail.

Approximately two years ago, the Agfa-Ansco Company, of Binghamton, N Y, made available a non-screen film having approximately twice the speed of regular x-ray film. Its emulsion was entirely different from regular x-ray emulsion, in that it was selective to the shorter wave lengths of x-ray rather than to the longer wave lengths emitted by intensifying screens. Because of its selectivity, this film could not be employed with intensifying screens.

The increased speed of the non-screen film, as compared with regular x-ray film when used without intensifying screens, was brought about with no sacrifice in detail sharpness, and it made possible the production of roentgenograms of increased brilliancy and contrast, even though the milliamperes-second value was only half that ordinarily employed for regular film used without screens.

The results obtained in the less opaque areas of the body, such as extremities, were a decided improvement over those obtained with regular x-ray film, but it was soon observed that the non-screen film showed the greatest improvement when the kvp value, rather than milliamperes-seconds, was decreased. This is because the non-screen film is more sensitive to secondary fog than is the regular film without screens, and an obvious result with an emulsion made selective to the shorter wave lengths.

Realizing that this increased sensitivity to secondary radiation might make non-

necessary a reduction in kv p to maintain the desired contrast. Comparison of roentgenograms made on the first non-screen film with those made on the new non-screen film, using the same kv p value with the Bucky diaphragm and changing milliampere-seconds only to maintain density, reveals no noticeable difference in contrast. Therefore, much has been gained and nothing lost by this increase in speed.

Dr Hollis E Potter, of Chicago, in his early work with the Potter-Bucky diaphragm, did not use intensifying screens. Using plates at the outset, and later duplitized film, his was undoubtedly the first non-screen Potter-Bucky procedure. At that time, however, it was necessary to use an enormous amount of energy, because of the slower speed of plates and films, and this imposed so many limitations that it was not considered practical for use generally.

Since this original work of Dr Potter's, there is no available record of a combined non-screen Potter-Bucky procedure for the heavier and more opaque areas of the body. We deem it a privilege, therefore, to present a thoroughly practical, non-screen Potter-Bucky diaphragm procedure, the result of which makes possible an entirely new standard of diagnostic value, as it may be effected by materially increasing sharpness of detail or definition.

We realize fully that there are other very important factors, some set and some variable, which can alter detail in a roentgenogram—for example, size of tube focal spot, focal-film distance in relation to object-film distance, motion of part or object during the exposure, and even grain size in the film itself. It is also realized that the work thus far must be considered as only preliminary. If sharpness of detail or definition is as important from a diagnostic standpoint as the radiologist has convinced us it is, then we believe that we are justified in presenting this new procedure as a ground work for something better in the future. There is no gainsaying the fact that, in the light of present knowledge, the

same sharpness of detail cannot be produced with intensifying screens as can be produced without, yet it is not beyond the bounds of possibility that future improvements in intensifying screens may make possible equally good or even better results.

In reviewing this work up to the present time, however, and since it was passed upon most favorably by several hundred radiologists at the Fifth International Congress, there seems to be no doubt but that this procedure may have a far-reaching effect in improving diagnostic results, particularly in the hands of the radiologist.

Results obtained thus far with non-screen Bucky diaphragm procedure may be compared to intensifying screen procedure by a somewhat broad division of the three distinct advantages which the non-screen procedure seems to offer: first, the improvement in definition or sharpness of detail, second, the extraordinary latitude present in this procedure, and third, the increase in visibility of certain structures which heretofore have been either invisible or could be made visible only through some highly specialized procedure.

DETAIL

Because the non-screen film is equally as fine-grained as the regular x-ray film, it is obviously necessary only to compare detail in films taken with screens with that in films taken without screens.

Therefore, insofar as actual detail sharpness is concerned, one need only consider, for example, the difference between films of a hand taken without screens and a hand taken with screens. This difference is so generally well known, however, that discussion seems unnecessary.

The problem of screen contact is, of course, ruled out entirely, as the non-screen film presents no problem of screen contact.

Obviously, the relation of focal-film distance or object-film distance to sharpness of detail will be the same with the non-screen film as it is with regular film used with screens.

The problem of motion and its influence



Figs 2 A, 2 B and 2 C These three roentgenograms were made with intensifying screens and regular film, using 7 milliamperere seconds on each 2-A was at 50 kv p, 2-B at 65 kv p and 3-C at 80 kv p

screen film Roentgenograms made with a sufficiently small effective focal spot permitted the use of a magnifying glass of between 2- and 3-power, without loss of detail sharpness

It should be obvious that any procedure which makes possible a considerably wider latitude in technic and, at the same time, produces diagnostic results of a higher order, is most desirable The non-screen film made this possible for the less opaque areas of the body, but energy requirements were such that it was not feasible to extend the procedure beyond the roentgenography of extremities, or other light areas such as the nose

A few days prior to the meeting of the Fifth International Congress of Radiology in Chicago, however, Agfa-Ansco more than doubled the speed of the non-screen film Experiments with several dozen of these films made available for the purpose of testing, proved not only that the new non-screen emulsion had more than twice the speed of the first non-screen film, but also that it was just that much more sensitive to secondary fog

Again the Potter-Bucky diaphragm procedure was employed, and, as in the case of the first non-screen film, secondary fog was entirely eliminated

Surprising as it may seem, the greatly increased speed of the film does not detract from its unusual latitude, nor does it make

Likewise, it will be found that this latitude varies, depending upon the part or area being exposed. For example, the latitude is not as great in the case of a part as thin as the hand, as it is for an anteroposterior lumbar spine.

GENERAL FILM QUALITY

One of the outstanding features of this film is a certain quality that is exceedingly difficult to describe successfully. The type of emulsion, and its so-called emulsion curve, probably bring about this change in quality which seems to be characteristic of all roentgenograms taken with it.

In the first place, we find that either with or without the Bucky, a change of 20 kv p is required within the range of 55 kv p and 90 kv p, in order to either double the film density or reduce it by one-half. That is, if the factor of penetration is being utilized as the variable, a change of approximately 20 kv p is necessary to actually double the density. This factor of 20 kv p is approximated, because again it will be found that the thickness of the part has something to do with the necessary change in penetration, to increase or decrease density a given percentage.

The effect of kilovoltage change when using this non-screen film with the Potter-Bucky diaphragm is considerably different than the effect of wide kilovolt peak changes when using films with intensifying screens. Inasmuch as this film does permit wide variations in penetration without materially altering the contrast, we find that for certain areas, such as the spine in the anteroposterior position, comparatively high penetration values are employed, which result in roentgenograms somewhat transparent in appearance. In other words, certain portions of the spine are distinctly visible, one portion through the other, yet despite this high penetration and visibility of the spine, the soft tissues are not eliminated. As a matter of fact, an excellent combination of bone and soft tissue delineation is obtained.

In addition, the character of the emulsion permits roentgenograms to be made of

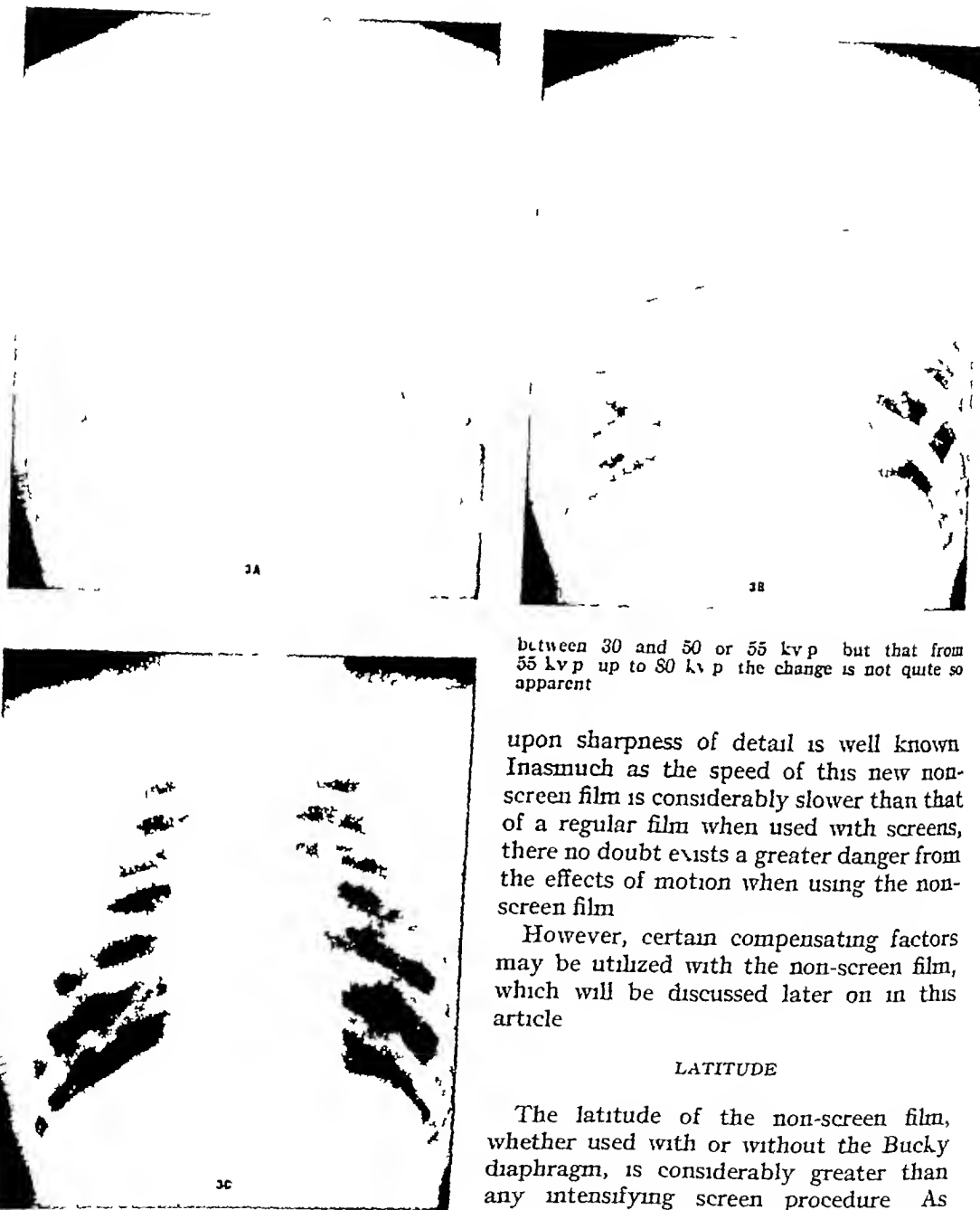
areas wherein a wide difference in opacity is shown, without the obliteration of areas of the least opacity. For example, in radiographing the chest with the speed-Bucky, we find it comparatively easy to make the dorsal spine distinctly visible, as well as the interspaces between vertebrae, and yet the lung structure itself is not obliterated. As a matter of fact, the lung structure is usually of about average density, despite the visibility of the dorsal spine through the heart shadow. Roentgenograms of heavy consolidated areas, with the Bucky diaphragm, will show that both the opaque and heavy consolidation have been well penetrated, yet other areas in the chest, and of considerably less opacity, are distinctly visible.

Thus we have results which are balanced in density, and under certain conditions this feature will be found to be very much worth while.

At the present time, at least, there are certain limitations to the widespread general use of this new non-screen film. The speed factor, for example, is such that for certain areas and for unusually heavy individuals, the energy necessary is completely outside the range of practical work. Therefore, intensifying screens are essential for these areas, and for those individuals coming under certain classifications.

Obviously, the best results will be obtained in those areas wherein a certain differentiation in structure exists. This is because the slower speed of the non-screen film, in comparison to films with screens, makes it impractical to reduce the penetration value below a certain point for certain areas, because of the tremendous increase in milliamperes-seconds which the lower voltage values would require. Consequently, certain areas are omitted from the accompanying technic chart, as well as certain limitations as to the size or thickness of the patient.

The actual speed factor of this film, compared to that of regular x-ray film without intensifying screens, is approximately 55 to 1. To explain further, all other factors being equal, slightly less than one-



Figs 3 A 3 B, and 3 C These three roentgenograms were made with the new Agfa non screen film—3 A at 50 kv p 3 B at 65 kv p and 3 C at 80 kv p In this instance 40 milliamperes seconds were used on each film The considerable difference in latitude as between the non screen procedure and screen procedure is distinctly shown As explained in this article the so-called factor of 6-1 as between these procedures must be approximate because of the variation in screen speed as penetration is changed It is generally understood that the speed of intensifying changes considerably

between 30 and 50 or 55 kv p but that from 55 kv p up to 80 kv p the change is not quite so apparent

upon sharpness of detail is well known Inasmuch as the speed of this new non-screen film is considerably slower than that of a regular film when used with screens, there no doubt exists a greater danger from the effects of motion when using the non-screen film

However, certain compensating factors may be utilized with the non-screen film, which will be discussed later on in this article

LATITUDE

The latitude of the non-screen film, whether used with or without the Bucky diaphragm, is considerably greater than any intensifying screen procedure As previously mentioned, the kv p value may be varied as much as five or six kilovolts above or below a given procedure, yet the change in density in comparison with screen radiographs is relatively small

It will be found, however, that the latitude, so far as voltage is concerned, is greater when using the Potter-Bucky diaphragm than when it is not employed

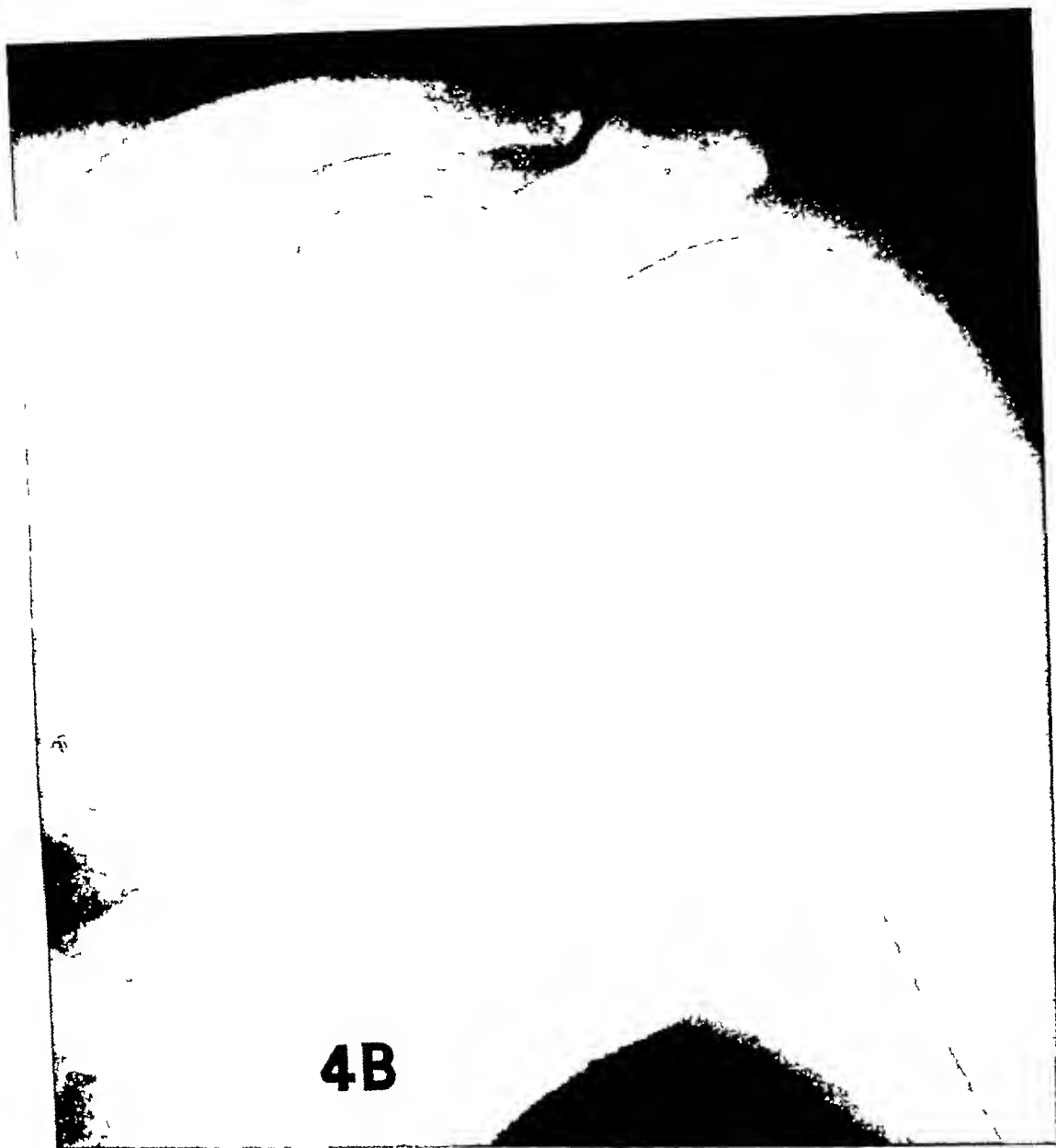


Fig 4 B (See opposite page)

ular film emulsion are entirely different in their characteristics

While it is perfectly true that when using the Bucky diaphragm with the non-screen film as compared with regular film and Par-Speed screens, there may be a difference of 600 per cent in exposure time at the same penetration value, there are certain compensatory factors which alter the situation

As already mentioned, wide voltage changes are permissible when using the non-screen film, furthermore, much higher penetration values can be employed with the non-screen film and the Bucky diaphragm, without detracting from its diagnostic value, than can possibly be employed when using intensifying screens

The fact that considerably higher penetration values can be utilized with the non-



Figs 4 A and 4 B (opposite page) Illustrating the difference in quality as between Bucky roentgenograms on regular film and Agfa non screen film

fifth the number of milliamperere-seconds are required for non-screen film as for regular film *without* screens. If it is desired to utilize the same number of milliamperere-seconds, and reduce the penetration instead of milliamperere-seconds, the difference is approximately 20 kv p.

In comparing the actual speed of this new non-screen film with that of the regular film when used with Patterson Par-Speed

screens, it will be found that the screen procedure at equal kv p values will require approximately one-sixth the number of milliamperere-seconds. Again we wish to point out that this is approximate, and that it will show certain variations, depending upon the thickness of the part as well as the penetration value.

It should be borne in mind, however, that the non-screen emulsion and the reg-



5B

Fig 5B Made with the Potter Bucky diaphragm and the new non screen procedure Factors employed 500 ma sec 30 inch distance 68 kv p and the 1 mm focal spot of the rotating anode tube

**5A**

Fig 5 4 Made with intensifying screens and regular film Factors employed 65 ma sec 36 inch distance 68 kv p

range of non-screen roentgenography than has been possible heretofore

A non-screen Potter-Bucky diaphragm procedure, for not only the thinner, less opaque areas of the body, but also for the heavier parts, is described

The generally improved roentgenographic quality, due to a decidedly increased sharpness of detail or definition when using this new non-screen film, seems to predict great steps forward in the production of diagnostic films

The procedure is one which, when placed in the hands of the specialist, gives great promise of making possible the diagnosis of very early pathology such as in many instances heretofore has escaped attention because of its invisibility

Definite technical procedures are given for various areas and parts of the body, wherein this film offers distinct advantages over roentgenograms taken with screens. These technical procedures have been carefully chosen to combine roentgenographic results of the highest quality, within practical energy requirements

It is believed that this new non-screen film opens up an entirely new diagnostic field, and that it is the fore-runner of a future roentgenographic quality, destined to add appreciably to the information which the specialist may obtain from roentgenographic studies, especially in cases in which diagnosis depends upon visibility of minute lesions

TECHNICAL PROCEDURE

The following technical procedures for the various areas and groups are based upon the utilization of a Potter-Bucky diaphragm and the new non-screen film

The procedure as given will naturally vary, particularly the penetration value, depending not only upon the preference in radiographic density, but also type of equipment, type of Potter-Bucky diaphragm, certain variables which may occur in the darkroom, and many other factors too numerous to mention

The specific values of kv p, however,

should not differ, under proper operating conditions, more than 10 kv p from these values given in the chart. In other words, a 10 kv p variation, up or down, on a particular equipment based upon the values as given, indicates a greater than normal variation

Inasmuch as greater energy than ordinarily employed with intensifying screens is utilized, care should be exercised at all times that the limit of the tube, as regards energy and cooling time, be given added consideration

The values as given are based upon kilovolts peak as the variable factor

Instead of definite milliamperage and exposure time values, the two are combined and milampere-second values are given. This in view of instances wherein x-ray tubes of widely varying capacity are employed. Therefore, milliamperage-second values and kilovolt peak values are based upon average working conditions, and with fresh chemicals

EXTREMITIES

This group includes the hand in both positions, wrist in both positions, elbow in both positions, shoulder, either antero-posterior or postero-anterior, foot, antero-posterior and lateral, ankle in both positions, knee in both positions

In this group it is deemed essential to use either a cone or a diaphragm, unless otherwise desired by the operator

Technic

200 ma -sec —40-inch distance—from
40 kv p for average hand to 73 kv p
for average shoulder

Head

Skull, P A or A P	200 ma -sec , 30-inch distance, 85 kv p
Skull, lateral	200 ma -sec , 30-inch distance, 75 kv p
Maxillary Sinus, P A	200 ma -sec , 30-inch distance, 85 kv p
Frontal Sinus	{ P A 200-ma -sec , 30-inch distance, 80 kv p
Ethmoid Sinus	

screen film (and should be utilized if proper quality is to be obtained) makes possible a reduction in milliamperere-seconds, which in roentgenography of the heavier areas, for example, would be approximately only twice that required with the intensifying screen procedure

Were it necessary to make up the difference in speed through the utilization of milliamperere-seconds alone, i.e., by a 600 per cent increase in either time or milliamperage, use of the new film would obviously be quite limited. Therefore, by compensating for a portion of this difference in speed, through the utilization of higher penetration values, it is ordinarily necessary only to double the milliamperere-second value usually recommended with intensifying screens. In some instances, the milliamperere-second value is virtually the same, the entire difference being made up in penetration—this applies particularly to areas of lesser opacity.

Because of the increased sensitivity of this film to the shorter wave lengths, and because of the difference in threshold speed between this film and the so-called regular film, it is essential that cones or diaphragms be employed for certain heavier and more opaque areas, in addition to the Potter-Bucky diaphragm.

In general, roentgenograms of the dorsal and lumbar spines, sacrum, and hip should be taken with a diaphragm or a cone, which, if square, should cover a film area no larger than 12×12 inches, in the case of a round cone, the diameter should not exceed 12 inches.

As with all procedures, non-screen or others wherein roentgenograms are made with the Potter-Bucky diaphragm, the smaller the area exposed, the greater will be the resultant differentiation of tissue.

It will be found that when smaller areas are exposed, a change in technical procedure must be made to compensate. That is, the smaller the exposed area, the greater the energy necessary, and *vice versa*. It is not practical to give any table, because of the wide variations in exposed areas due to variable focal-film distances, variable sizes

in cones, or variable sizes in diaphragms.

The processing technique with this non-screen film is practically the same as for regular film, with some modifications. Our best results thus far, from the standpoint of developing, have been 7 minutes at 68° F, 5.5 minutes at 70° F, 4.5 minutes at 72° F. Our experiments seem to indicate that 65° is about the minimum temperature that can be successfully used, even though compensation is made by increasing the developing time. That is to say, at 65° the developing time is of the order of 9 or 10 minutes, while at 63°, 13 to 15 minutes are required.

The non-screen film should be developed by timing because of the difficulty of visual inspection. With the average red light in the darkroom, the film appears to be perfectly black.

Between the developer and the fixing bath, at least 10 seconds' rinsing is required.

It will be noted that this film requires approximately double the time to fix completely, as regular x-ray emulsion. This is particularly true where a considerable amount of unexposed film area must be fixed.

It will be noted generally that after the film has been fixed, a smoky appearance remains. This can be removed in the wash water. If the fixing bath is fresh, it may take 5 to 10 minutes to remove all of this discoloration—less as the fixing bath gets older.

The film should be washed the same length of time as for regular x-ray emulsion.

Because of the difficulty of properly demonstrating sharpness of detail through reproduction, the accompanying illustrations and comparisons really do not do this new film justice. However, we have attempted to bring out certain features of the film, as explained with each illustration.

CONCLUSION

A new non-screen film is described which, because of its general characteristics and high speed, makes it adaptable for a wider

proximately 9.5 inches in thickness usually is not improved through the use of the non-screen film

When the Potter-Bucky diaphragm is employed, using the technical procedure as given above, virtually any chest thickness will show a decided improvement, from the standpoint of detail sharpness. Ordinarily chest procedure with the Potter-Bucky diaphragm is undertaken when certain types of pathology exist—particularly consolidation. It is in this type of work that the non-screen Potter-Bucky diaphragm procedure should add considerably to the diagnostic value of the chest roentgenogram.

This new type non-screen film has been

available only about six weeks. During this time, it has been necessary to accumulate just as much information as possible in order that such information might be passed on, even though it be purely preliminary.

I wish to express my sincere thanks and appreciation to my co-workers, without whose co-operation it would have been impossible to present a preliminary report at this time. Messrs. H. O. Mahoney, J. B. Thomas, F. G. Davis, J. Dee, John Armstrong, Charles Minnich, M. Fagen, and Paul Freer. They have worked diligently in order that more than two thousand roentgenograms and comparative studies could be made in these few short weeks.

Sinuses, lateral 200 ma -sec , 30-inch distance, 70 kv p

Mastoid, lateral 200 ma -sec , 30-inch distance, 80 kv p

Nose, lateral 200 ma -sec , 40-inch distance, 65 kv p

It is recommended that a cone or diaphragm be used to cover exactly the area or part. In the case of a lateral skull, for example, the cone should be sufficiently large to include the entire skull. On the other hand, in the case of an area such as a mastoid, the cone should be only large enough to cover the area desired.

Trunk

Atlas—Axis, A P (mouth open) 200 ma -sec , 22-inch distance, 60 kv p

Cervical Spine, A P and lat 200 ma -sec , 40-inch distance, 75 kv p

Dorsal Spine, A P 200 ma -sec , 40-inch distance, 80 kv p

Dorsal Spine, lat 200 ma -sec , 40-inch distance, 70 kv p

Note The technical procedure for the dorsal spine in the lateral position is based on the patient taking a full breath and holding it during the exposure.

Lumbar Spine, A P , 400 ma -sec , 36-inch distance, 70 kv p

Sacrum, A P 400 ma -sec , 36-inch distance, 70 kv p

Pelvis or Hip, A P 400 ma -sec , 40-inch distance, 70 kv p

Sternum, P A 200 ma -sec , 25-inch distance, 60 kv p

Sternum, lat 100 ma -sec , 36-inch distance, 75 kv p

Ribs, A P or P A	{	Above diaphragm 100 ma -sec , 30-inch distance, 70 kv p
		Below diaphragm 200 ma -sec , 30-inch distance, 75 kv p

Organs

Chest P A	{	Without Bucky 40 ma -sec , 48-inch distance, 70 kv p
		With Bucky 80 ma -sec , 48-inch distance, 75 kv p

Kidney, A P 150 ma -sec , 36 inch distance, 70 kv p

Urinary Bladder, A P 150 ma -sec , 36 inch distance, 75 kv p

Gall Bladder, P A or A P 150 ma -sec , 30-inch distance, 70 kv p

Stomach	{	P A or A P 150 ma -sec , 30-inch distance, 75 kv p
		Semi-lateral 150 ma -sec , 30 inch distance, 80 kv p

Colon, A P 150 ma -sec , 40-inch distance, 80 kv p

For radiography of infants and children, using a non-screen Potter-Bucky diaphragm procedure, it will be found advisable to either reduce the penetration 15 to 20 kv p from the values given for average adult in the above group, or reduce the milliamperes-seconds to half that given above, and utilize the recommended kv p for adults.

To reiterate, the above given settings can be considered only approximate, but they should serve as a starting point, rather than to leave everything to conjecture. Insofar as is practical, it is our belief, based on our experiences to date, that the milliamperes-second value should be maintained as nearly as possible. The distance values as given may, of necessity, have to be changed, depending upon the installation. In the event that the distance must be changed, which under ordinary circumstances would be a reduction, then the milliamperes-seconds may be changed according to the inverse square law.

In radiography of areas such as kidney, lumbar spine, hip, sacrum, etc., it is recommended that not only a rubber bag be employed as a means of compression, but also an immobilizing band, usually available wherever the Potter-Bucky diaphragm is used.

It is difficult to stipulate any limitation either as regards thickness of part or type of individual. However, in the case of chest radiography without the Potter-Bucky diaphragm, our experience thus far has indicated that a chest in excess of ap-

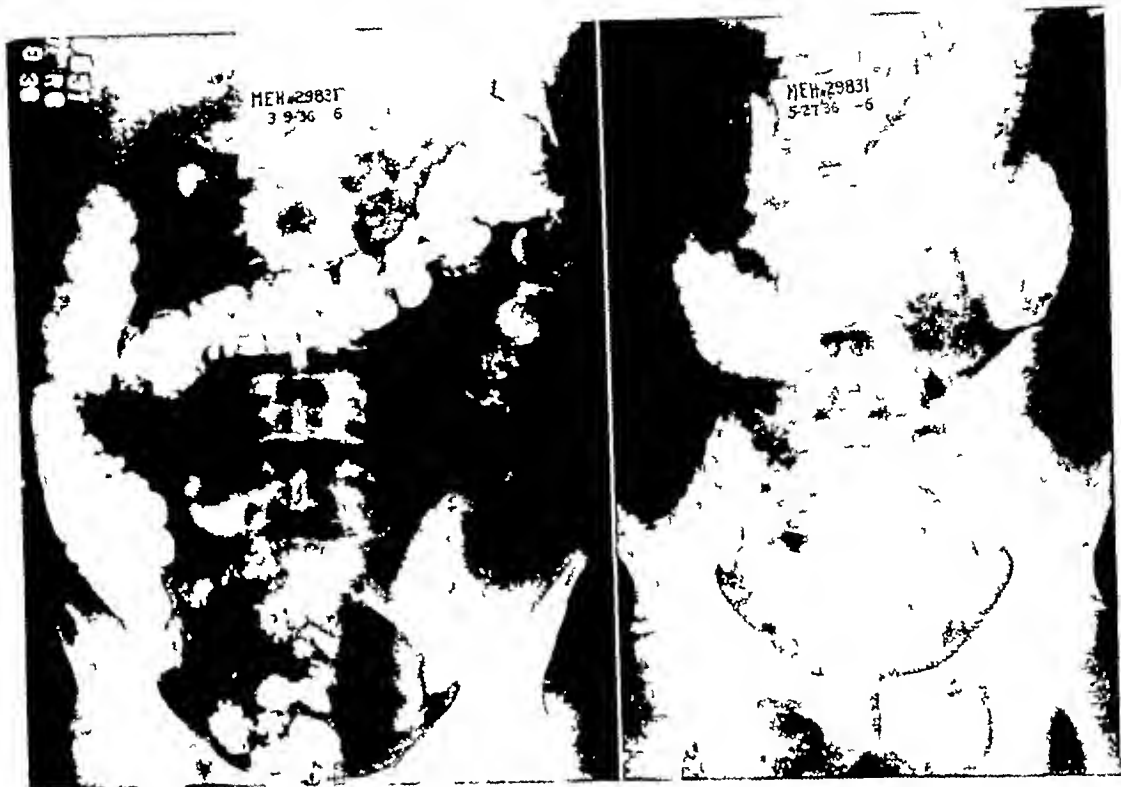


Fig 2 (left) Case 1 Appearance six hours after barium meal, March 9 1936
 Fig 3 (right) Case 1 Retention of barium in stomach and jejunum six hours after barium meal, May 27, 1936

meals, unaffected by food or alkalis, and accompanied by occasional nausea and vomiting. Loss of weight, appetite, and strength are quite common. A change in bowel habits with the appearance of diarrhea or constipation, bloody or tarry stools, is also common. Abdominal distention and flatulence are sometimes reported. The acute symptoms—which are sometimes all that the patient ever has, but more often follow a period of indefinite complaints—are ushered in with more frequent to persistent vomiting, cramping abdominal pains that become localized, marked loss in weight, abdominal distention, and constipation or occasionally a bloody diarrhea.

The physical findings in the acute stage are usually those of dehydration, some emaciation, abdominal distention, visible peristalsis, and occasionally a palpable tumor mass. The laboratory findings often indicate a secondary anemia, a depletion in free HCl to complete achlor-

hydria, evidence of dehydration, and the presence of blood in the stool.

The roentgen findings are those of incomplete to complete small bowel obstruction. The stomach and duodenum are usually normal except in those cases in which the carcinoma also involves the duodenum. If the obstruction is high up in the jejunum, there may be considerable dilatation of the duodenum and stomach with reverse peristalsis. There is usually a retardation in the passage of the barium meal through the small bowel, and sometimes complete obstruction with retention of the barium for periods of 24 hours or longer. It is sometimes possible to discern an abrupt demarcation between the involved and uninvolved portions of the bowel and an obliteration of the mucosal relief at the site of the lesion as described by Nettrour (21). The colon is usually normal but it should always be examined in questionable cases.

The treatment is surgical when the diag-

CARCINOMA OF THE JEJUNUM

By BERNARD KALAYJIAN, M D, *Charleston, S C*

Report of work done in the Department of Roentgenology, Methodist Hospital, Indianapolis, Indiana

CARCINOMA of the small bowel occurs infrequently enough to stimulate more than ordinary interest from a diagnostic standpoint. According to Barnhart (3), 77 such cases had been reported up to 1931. Since that time, the author has been able to find approximately

evidence in the literature of predisposing factors or hereditary effects.

The pathology is usually that of an annular adenocarcinoma, although other types such as malignant degeneration of polyps, malignant transformation of pancreatic rests, colloid carcinoma, and expansive



Fig 1 Case 1 Posterior anterior and oblique views of stomach and duodenum March 9 1936

35 additional case reports. Since the diagnosis of this disease can frequently be made by the roentgenologist alone, the author wishes to add two cases to the literature, in one of which a pre-operative diagnosis of carcinoma was made from the roentgen findings.

The exact etiology of this disease is unknown. Multiple reasons for the infrequency of carcinoma in this region have been given, including the fluid content of the bowel, the alkalinity of this content, and the absence of sharp bends in the bowel. The age incidence is approximately the same as for other carcinoma. The average age is variously given, but most authors agree on 47 or 48 years. The case reports indicate a predominance of males in a two-to-one ratio. There is no

ulcerated and non-ulcerated lesions have been described. The annular lesions are almost invariably constricting in type. Metastases are frequently found rather early, according to the more recent authors, although in the past it has been considered that this type of carcinoma metastasized rather late. The metastases are first to the local lymph glands, then to the liver, long bones, lungs, ovary, dura, etc.

The symptoms of the disease depend largely on the speed of development of mechanical bowel obstruction by the tumor mass, rather than on cachexia from the tumor itself. In the slowly growing tumors, there is often a period of from three months to a year or more, in which the patient complains only of indefinite abdominal distress, which is unrelated to

left upper quadrant in the jejunum, and a small amount had passed through into the colon. At 32 hours (Fig 5) the stomach had been partially refilled, by reverse peristalsis, from the barium retained in the jejunum. A diagnosis of almost complete obstruction in the jejunum or upper ileum possibly produced by a tumor, was, therefore, made.

At operation, an annular hard tumor mass was found in the jejunum approximately two feet from the ligament of Treitz. There were multiple firm enlarged lymph glands in the mesentery. There was fixation of the mass to surrounding structures so that it was impossible to resect the tumor. An anastomosis was made around the lesion. One of the glands and a biopsy section of the tumor mass were taken for study. The pathologic report indicated adenocarcinoma of the jejunum with lymphatic metastases. Recovery was slow but uneventful.

This patient was last seen on Dec 7, 1936. He had no abdominal complaints at this time and had gained 40 pounds in weight. He had a good appetite and no vomiting. Roentgen examination of the upper gastro-intestinal tract revealed a normal stomach and duodenum except for some indentations of the lesser curvature of the duodenum by firm masses which we felt were metastatic nodes (Fig 6). The motility through the small bowel was normal if not a little rapid, as the stomach and small bowel were empty at the end of three hours (Fig 7).

This patient died in May, 1937, approximately one year after operation. No autopsy was obtained.

Case 2. M. M., a white female, 60 years of age, was admitted on March 22, 1937, with complaints of vomiting and constipation. The vomiting had started three weeks previous to her entry, had increased in frequency, and although at times bile-stained material was vomited, it no time was there a fecal character to the vomitus. Her appetite was good, but she could retain little or no food. There was no particular pain associated with the



Fig 5 Case 1 Stomach refilled by reverse peristalsis from barium retained in jejunum 32 hours after barium meal May 28, 1936

vomiting. The constipation had been present for many years but had increased recently. There was no history of bloody or tarry stools obtainable. There had been loss of weight—ten pounds in three weeks.

Physical examination revealed a small elderly female with normal chest findings, some distention of the abdomen, no palpable abdominal masses, and visible peristalsis across the upper abdomen. The other findings were normal. There were no palpable lymph glands.

Laboratory examinations revealed red blood corpuscles, 4,050,000, hemoglobin, 80 per cent, blood chlorides, 522 mg, total non-protein nitrogen, 75.8 mg, Ewald free acid 8, combined 44, lactic acid positive, Wassermann test, negative, and occult blood in stool.

Roentgen examinations revealed a marked dilatation of the stomach without pyloric obstruction and some dilatation of the duodenum to the duodeno-jejunal juncture, at which point there was a definite constriction of the lumen for approxi-



Fig 4 Case 1 Stomach practically empty, barium retained in jejunum and small amount in colon 24 hours after barium meal May 28 1936

nosis has been established. Resection of the tumor mass and anastomosis of the adjoining portions of the bowel is given as the method of choice. In those cases in which resection cannot be carried out, some form of palliative operation for relief of the obstruction is often performed. The prognosis is not good in any event. Rankin (24) reports no cases living over three years. Lynch (15) reports a case known to have lived for six years. Kordenat (14) states that the average length of life is 18 months after operation.

CASE REPORTS

Case 1 D C, a white male, 39 years of age, was first seen by the author as an outpatient on March 7, 1936. At that time he was complaining of vague abdominal distress, which did not become localized, and was accompanied by occasional nausea and vomiting. He had some diarrhea but not tarry stools. All these symptoms had

started about three months previously except for the diarrhea, which first appeared three weeks after the first pain and vomiting, continued for six weeks, and then stopped. There was never any blood, mucus, or pus in the stool. Roentgen examinations then revealed a poorly functioning gall bladder without stones, a normal stomach, and duodenum with normal motility of the barium through the small bowel at six hours (Figs 1 and 2), a slightly dilated colon which had normal emptying power and a visualized appendix which was not tender to palpation.

The patient was next seen after his entry in the hospital May 26, 1937, with complaints of frequent vomiting, loss of weight and strength. The vomiting occurred more and more frequently, and at the time of entry he could retain only soft food. The abdominal pain he had was transient, very slight, and not related to meals. There was no localized abdominal discomfort and no distention. He had lost over 60 pounds in weight during the previous five months. His past history bore no connection to his present illness. There was no history of carcinoma in the family.

Physical examination at this time revealed an emaciated white male with normal heart and lungs, slight distention of the abdomen with some occasional visible peristalsis across the upper part, and palpable inguinal glands. All other findings were essentially normal.

The laboratory examinations revealed red blood cells 4,170,000, hemoglobin, 84 per cent, white blood cells, 8,300, urine, essentially normal, phenolsulphonaphthalein test, 64 per cent, blood chlorides, 417 mg, Wassermann test, negative.

The roentgen examination at this time revealed a normal stomach and duodenum, and a definite delay in motility of the barium through the small bowel. At six hours after the barium meal (Fig 3) there was a considerable retention in the stomach and jejunum and no barium in the loops of the ileum or the colon. At 24 hours (Fig 4) the stomach was practically empty, most of the barium was collected in the

left upper quadrant in the jejunum, and a small amount had passed through into the colon. At 32 hours (Fig 5) the stomach had been partially refilled, by reverse peristalsis, from the barium retained in the jejunum. A diagnosis of almost complete obstruction in the jejunum or upper ileum possibly produced by a tumor, was, therefore, made.

At operation, an annular hard tumor mass was found in the jejunum approximately two feet from the ligament of Treitz. There were multiple firm enlarged lymph glands in the mesentery. There was fixation of the mass to surrounding structures so that it was impossible to resect the tumor. An anastomosis was made around the lesion. One of the glands and a biopsy section of the tumor mass were taken for study. The pathologic report indicated adenocarcinoma of the jejunum with lymphatic metastases. Recovery was slow but uneventful.

This patient was last seen on Dec 7, 1936. He had no abdominal complaints at this time and had gained 40 pounds in weight. He had a good appetite and no vomiting. Roentgen examination of the upper gastro-intestinal tract revealed a normal stomach and duodenum except for some indentations of the lesser curvature of the duodenum by firm masses which we felt were metastatic nodes (Fig 6). The motility through the small bowel was normal if not a little rapid, as the stomach and small bowel were empty at the end of three hours (Fig 7).

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Fig 6 Case 1 Notching of lesser curvature of the duodenum by metastatic nodules Dec 7 1936



Fig 7 Case 1 Appearance three hours after barium meal Dec 7, 1936

mately one and one-half inches. There was considerable reverse peristalsis and churning of the barium meal in the duodenum with occasional passage of a small amount beyond the point of obstruction. There was a large retention in the stomach at 24 hours, and not over 20 per cent of the barium passed the obstruction. The colon was essentially normal. A roentgen diagnosis of obstruction at the duodeno-jejunal juncture produced by a carcinoma was made.

At operation a stony hard, annular tumor at the duodeno-jejunal juncture was found, with adjoining masses of enlarged hard lymph glands. The gall bladder was stony hard, white, and fixed in position. It was thought inadvisable to attempt resection of the tumor mass, so biopsy section was made and one of the glands removed, and then a gastro-enterostomy was performed. The surgeon believed the pathology to be a primary carcinoma of the gall bladder with secondary tumor growth about the bowel. The pathologic report indicated a carcinoma originating in the epithelium lining the biliary ducts. Recovery was uneventful, and no further

reports have been obtainable on the progress of this case.

In summary, the author wishes to emphasize

1. Carcinoma of the small bowel is not as uncommon as was formerly believed.

2. Patients with indefinite abdominal distress, vomiting which increases in frequency, and occult blood in the stool should be carefully examined for the presence of small bowel malignancy. Examination of the stomach, duodenum, and colon is not enough; too often these are found to be negative and the patient dismissed. Careful, persistent, and repeated examinations of the small bowel are necessary if more accurate diagnoses of these obscure cases are to be obtained.

In addition to the direct references, the author has included in the bibliography many of the recent articles on this subject.

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RECENT ADVANCES IN DIAGNOSIS FROM AND TECHNIC OF CHOLECYSTOGRAPHY¹

By HERMAN B. PHILIPS, M.D., *New York City*

THIRTEEN years have passed since the advent of the Graham test in roentgenology. As is usual with all new diagnostic procedures, it has taken some time to establish its real worth. Considerable stress used to be placed on the intravenous method of examination, but accumulated experience and improvement in technic of the oral method have placed the latter on a par with the intravenous method. Marked impetus was given oral cholecystography about three years ago by the introduction of the so called "intensifying technic," by Stewart and Illick (1). It combines the methods of Antonucci and Sandstrom, the former by utilizing glucose to aid in more rapid absorption of the iodine by the liver and the latter by using fractional doses of the tetraiodo at more frequent intervals and over a longer period of time.

Credit must be given several roentgenologists for their contributions toward the development of cholecystography and establishing it to day as a definite, exact method of diagnosis. Among these are Leonard, George, Sosman, Kornblum, Hall, Pendergrass, Hodes, Ettinger, Newcomer, Boyden, McNamee, Moore, Kirklin, Blake, Jenkinson, Stewart, and Illick. The statement is warranted, that the amount of accuracy of information obtainable from cholecystography is directly proportional to the care, precision, and attention to details in the course of the examination. Without these, the results are confusing and the examination of little or no value.

As much attention must be given to the details concerning food ingestion and the administration of the dye as to technic of the examination. We have used the dye in capsule form because we have consistently found that better than other forms of

administration. Patients are given type-written instructions and advised to follow them to the letter. They are as follows:

- 1 During the afternoon have several cups of tea with excessive amounts of sugar
- 2 Have a regular dinner at six o'clock.
- 3 Take six capsules one hour later
- 4 During the evening have two or three cups of tea with excessive amounts of sugar
- 5 Have a breakfast consisting of fruit juices and tea with excessive amounts of sugar
- 6 Have a luncheon consisting of fruit juices, fruit salad, jello, and tea with sugar
- 7 Take six capsules one hour after lunch
- 8 Have the same dinner as luncheon
- 9 Take six capsules one hour after dinner
- 10 Report for x-ray examination at ten o'clock the following morning without further food or drink.

The initial phase of our examination, after making sure that the patient has followed our instructions to the letter and ascertaining whether there has been any vomiting or diarrhea and the probable influence of same on the success of our examination, is to place the patient in a prone position on the table and make an 8 X 10 roentgenogram of the gall-bladder region. The exposure is a postero-anterior one, centering over a point half way between the middle of the spine and the tip of the last rib. A large cone is used with the Bucky diaphragm. This constitutes a scout film. In the event that the gall bladder is seen, its position relative to the last rib and iliac crest is noted and several films are now made with a small or dental cone, some of them at long distance, some oblique or lateral, some in the Trendelenburg position or erect, in order to bring out all possible fine details of the cholecystogram. This method requires processing and studying each cholecystogram in succession, so as to permit variations in technic to eliminate extrinsic positive and negative shadows and to allow one properly to evaluate

¹ Presented at the Clinical Conferences of the Park East and Park West Hospitals New York City during 1937

intrinsic ones. In the event that no gall bladder is seen, a 14×17 roentgenogram is made to include the entire liver and gastro-intestinal tract. This will show whether or not a left-sided gall bladder is present, and, what is more important, the amount and condition of the dye in the intestine. It may be found that the dye is in its original form, the same as before ingestion, and no cholecystogram can be expected, or there may be heavily precipitated dye, which also is unsatisfactory and only occasionally accompanied by success in the examination. If the dye is found in the intestine in an extremely fine, subdivided, flaky state, and in considerable amounts and the gall bladder does not visualize, it may be considered definitely that a pathologic condition is present in the biliary tract. This determination of the presence of sufficient amounts of dye in a finely subdivided state (as excreted from the liver into the small and large intestine) precludes the necessity for considering systemic disturbance as playing any part in non-visualization. Previously, peritoneal irritation, as from an ulcerative lesion of the gastro-intestinal tract, a severe colitis, hyperthyroidism, extreme asthenic states, pregnancy, severe cardiac failure with passive congestion, ulcerative lesions of the stomach or duodenum, and diabetes were considered as influencing the cholecystographic examination and as being responsible for non-visualization. Since the introduction of the special intensifying technic, most of these fail to interfere with satisfactory cholecystography and the only real deterring factors are those of a mechanical character, such as obstruction of the pylorus or duodenum, so that the dye cannot be carried into the small intestine to be absorbed, or an intense diarrhea with too rapid evacuation of the dye with prevention of absorption in sufficient amounts.

The examination after a motor meal is extremely important and merits special comment. Roentgenograms are made one-half hour and one and one-half hours after the meal is ingested. The gall bladder

should be partially contracted and emptied. It is at this stage of the examination that adenomas are most frequently visualized. The same obtains for some opaque and non-opaque calculi, either casting only suspicious shadows or none at all, in the roentgenograms made prior to the motor meal. If the gall bladder emptying is retarded, another roentgenogram is made after another hour and occasionally after twenty-four hours, in cases in which extreme delay of emptying is noted.

A few years ago the opinion was quite prevalent that if a gall bladder did not visualize it was not necessary to continue the examination with a motor meal and further roentgenograms. We have encountered at least five cases in which a motor meal served to fill the gall bladder with dye with good concentration, in which it previously was not seen. This phenomenon has been explained on a mechanical basis by Newcomer and Newcomer (2), who have shown that there may be a natural kink or twist in the cystic duct which is straightened out by tension on or pressure by the pylorus when the pylorus is filled with food, permitting the dye to go into the gall bladder. These authors also claim emptying of the gall bladder solely on a mechanical basis, that fatty foods are not essential to empty the gall bladder, but that compression of the gall bladder by the active peristaltic pylorus after food ingestion is responsible for emptying. It is, therefore, indispensable in all cholecystographic examinations to include at least one roentgenogram after a motor meal. If all of the above details have been considered and provided for in the examination, it is justifiable to assume that non-visualization of a gall bladder indicates a pathologic condition of the liver, bile ducts, or gall bladder, which either prevents excretion of the dye, transmission of the dye, or storage of the dye, respectively. According to Hodges and Lampe (3), there is 80 per cent accuracy of the conclusions based on non-visualization, as checked by operation.

Non-visualization of the gall bladder



Fig 1 (left) Gall bladder not visualized by "intensified" technic (Aug 31, 1934)
 (Right) Cholecystogram with good concentration normal contour, no calculi after three months of "medical" treatment for a chronic cholecystitis (Dec 3 1934)
 This case illustrates the need for conservative estimate of non visualization value of conservative treatment, and serial studies

should not be accepted as an absolute indication for surgical intervention, for a transitory inflammatory condition may be present and cause sufficient obstruction of the cystic duct to prevent the dye entering the gall bladder. This may subside rapidly under conservative medical therapy. Unless the symptoms are very severe or calculi are demonstrated, conservative treatment, followed by another cholecystographic examination, may show a fairly normal cholecystogram subsequently (Fig 1). This point was stressed emphatically by Jenkinson (4) in September, 1936, and if followed, the small percentage of errors will be still further diminished.

Occasionally gas or dye shadows in the colon overlap the cholecystogram, resulting in very confusing shadows. To remove them, it has been recommended that pitressin be used hypodermically. We have not been convinced that this is valuable, but do find that the simple procedure of administering a high hot enema eliminates all gas and dye shadows in the colon

and permits of a much more satisfactory continuation of the examination.

In the interpretation of positive and negative shadows in the roentgenograms, suspicious of gallstones, one must make use of technical variations including changes in position of the patient. Lateral and oblique roentgenograms serve to eliminate persistent confusing gas shadows which sometimes cannot be differentiated from the negative shadows of pure cholesterol calculi. Variations in position of the patient are also indispensable in differentiating positive shadow calculi from congenital malformations of the gall bladder ("Phrygian caps" and pseudo-diverticula), some of which cannot be differentiated from calculi by any other method. Erect and Trendelenburg roentgenograms are useful in differentiating negative shadow calculi from papillomas, adenomas, or other tumors, in which case calculi can be made to move around in the gall bladder, while the tumors will remain in a fixed relative position. The erect roentgenogram is

essential in demonstrating very small, radiolucent cholesterol calculi, not seen in routine horizontal exposures

THE NORMAL

Before considering the pathologic, it is essential to consider what the normal findings are in a cholecystographic series. The gall bladder may show up clearly by means of the intensified technic with a density as great as, or greater than, that of the adjoining bony structures, and frequently equalling that found in the hollow viscera in the course of an opaque meal examination. Kirklin and Blake (5) have stressed the importance of judging the cholecystogram by its best appearance and considering it normal unless the shadow is so delicate that its borders can be traced only with difficulty. The gall bladder should be homogeneous in density and smooth in contour. The position varies with the type of patient and follows, with occasional exceptions, the general rules of habitus that obtain for the position of the stomach and intestines. In the course of a routine examination, roentgenograms should be made one-half hour and one and one-half to two hours after the ingestion of a motor meal, our motor meal for the last few years comprising two eggs and one-quarter of a glass of cream with anything else that the patient chooses to take. The post-motor meal roentgenograms should show definite evidence of contraction of the gall bladder with diminished size of the gall bladder, but no evidence of irregularities in contour or density. The roentgenogram made thirty minutes after the motor meal may show the cystic duct, but this lack of visualization of the cystic duct should not be regarded as an indication of a pathologic condition. If information about the cystic and common ducts is desired, the routine may be altered so as to have the patient in the supine position, an anteroposterior roentgenogram being made instead of the usual postero-anterior one in the prone position. This frequently facilitates filling of the cystic and common ducts. The one and one-half

hour roentgenogram should show more complete emptying and contracture of the gall bladder. At least two roentgenograms should be made following the motor meal, preferably at the time-interval outlined above. If the gall bladder does not empty, further examinations should be made after twenty-four hours.

PATHOLOGIC GALL BLADDER

The pathologic gall bladder varies from complete non-visualization to very faint visualization. If persistent roentgenographic examination with the most careful technic and diaphragming, following the plan outlined in the introductory remarks, fails to reveal a gall bladder with sufficient clearness to permit of a definite outline, some abnormality must be considered to exist. A large gall bladder must be regarded as pathologic. Irregular calcification of the costal cartilages are frequently a source of error in interpreting the border of gall bladders, as well as confusing in the interpretation of stones within the gall bladder. Oblique and lateral roentgenograms will definitely exclude these shadows and determine their actual character. A new nomenclature was suggested by Pendergrass and Hodes (6) in 1935, based on apparent functional capacity. They enumerate three general classes. The classification has met with general approval for it lends itself to a most conservative and accurate estimate of the gall-bladder condition. It is as follows:

Gall bladder maintains some function, no matter how diseased it may be

- I "Functioning gall bladder"
 - (a) "Functioning gall bladder with stones"
 - (b) "Functioning gall bladder with mural growth (papilloma)"
 - (c) "Functioning gall bladder with adhesions"
 - (d) "Functioning gall bladder with anomalies"
- II "Partially functioning gall bladder"
 - (a) "Partially functioning gall bladder with stones"
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Fig 3 Intra-hepatic gall bladders (two cases) Dotted lines show lower borders of liver Gall bladders are transversely placed (See text)

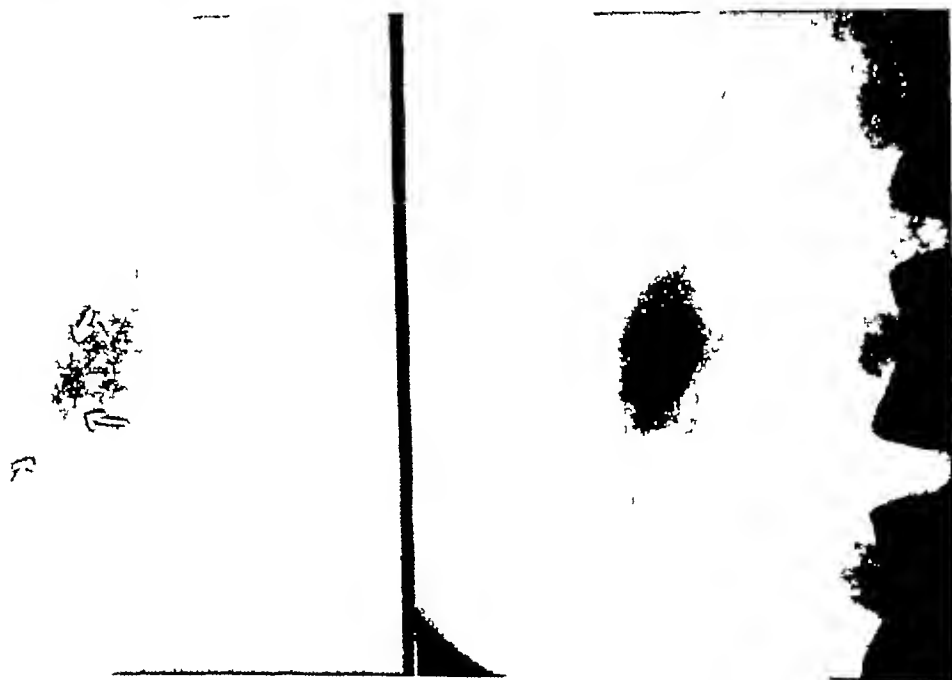


Fig 4 Phrygian cap gall bladder at different angles showing the constriction and deformity of the fundus producing a pseudo-diverticulum seen in profile on the right, whereas on the left the diverticulum is overlapped by the rest of the gall bladder and produces a shadow indistinguishable from a 'positive shadow' calculus

CHOLELITHIASIS

The accuracy of the diagnosis of calculi hinges mostly on refinements in technic

and is directly proportional to the precision and thoroughness of the examination. The most valuable of these is the liberal



Fig 2 Negative shadow ' calculi are easily confused with air shadows in superimposed colon. Positive differentiation by oblique and lateral roentgenograms.

(Upper left) Negative and positive shadow calculi persistent at all angles

(Upper right) Three or more negative shadow' calculi present in lateral and oblique roentgenograms

(Lower left) Lateral roentgenogram shows persistent 'negative shadow' calculus other confusing negative shadows being eliminated

(Lower right) Extrinsic negative shadow from hepatic flexure eliminated by lateral roentgenogram.

III "Abnormally functioning gall bladder"

(a) "Abnormally functioning gall bladder with stones"

(b) "Abnormally functioning gall bladder with anomalies"

(c) "Calcified gall bladder"



Fig 7 Milk of calcium bile gall bladder (*Left*) Prone (*Right*) Erect, showing fluid opaque bile. Calculi in cystic duct clearly seen in three other cases. Gall bladders usually small and contracted. Any blotchy opaque shadow encountered in the upper right quadrant, without dye series, should be examined in the erect position to exclude milk of calcium bile gall bladder.

test. The pre-operative information that the gall bladder is all or partially buried in the liver substance should be of inestimable help to the surgeon.

"PHRYGIAN CAP" GALL BLADDERS

Irregularities in contour of the gall bladder, until a few years ago, were considered, almost uniformly, as being caused by deforming gall-bladder adhesions. An illuminating article on this subject by Boyden (8) throws considerable light on these defects, and it is a safe statement to make that most of the irregularities in a gall bladder that is not markedly contracted or poorly visualized, are due to congenital anomalies of development. In Boyden's experience 18 per cent of cholecystograms showed "Phrygian caps." There are two groups, the concealed (or retroserral type) and the serosal type. In the latter, which is the more common type, the deformity is fixed by fetal ligaments or constrictions of the lumen, the peri-

toneum following the folds in the gall bladder. In our experience, when the deformity is marked it lends itself to confusion, and exposures from several angles are essential to clarify the diagnosis. The pouching of the fundus may produce pseudo-diverticula, and in one instance the overlapping of a diverticulum by the gall bladder gave a shadow indistinguishable from a positive calculus (Fig 4). There is no particular clinical significance to these anomalies. They are not associated with any symptoms, they show no roentgenological or other indications of disturbance in function (Fig 5).

THE ERECT CHOLECYSTOGRAM

All cholecystographic examinations should include at least one roentgenogram made in the erect position. While this procedure has been stressed earlier in the paper under technical considerations, elaboration is essential to emphasize its importance in the detection of minute calculi.



Fig 5 Other cases of "Phrygian cap" gall bladders showing the marked deformities easily misinterpreted by those unfamiliar with the anomaly

utilization of examination of the patient in the lateral, oblique, and erect, and occasionally in the Trendelenburg positions, particularly during the post-motor meal period. In the latter, either by deposition of the dye on the surface of radiolucent gallstones or by the elimination of part of the dense superimposed opacity of the dye-containing bile, it is feasible

to definitely demonstrate calculi with considerable certainty. There should be exceedingly little room for doubt in a dye series, if all these details in technic and procedure are carried out to the letter. Occasionally two calculi—a positive and a negative shadow—are seen in the same gall bladder, the former seen through the latter (Fig 2). Most of the confusing negative shadows are produced by air or dye in the colon, but if these are not eliminated by a hot enema, the exact character of these shadows can be determined in almost every instance by utilizing oblique and lateral roentgenograms (Fig 2).



Fig 6 Erect cholecystogram to demonstrate minute cholesterol calculi which float between biles of different concentrations at their interfaces. (Reproduced through courtesy of Dr. Alice Ellinger and the "American Journal of Roentgenology and Radium Therapy".)

INTRA-HEPATIC GALL BLADDERS

In the last few years, I have found what appear to be roentgenologically (unconfirmed by operation), three cases of intra-hepatic gall bladders. These have been situated transversely with the gall bladder, more or less embedded in the liver substance (Fig 3). They may present considerably above the liver border, appearing like cysts, or they may show only as dimples on the undersurface or along the lower border of the liver. McNamee (7) reported two cases of intra-hepatic gall bladder. In one, the organ could not be found at laparotomy for it was completely buried in the liver substance. However, it was visualized again in a second Graham

tion of this condition by Kornblum and Hall (10) in May, 1935, I encountered four cases in the following year, only two of them in the course of gastro-intestinal studies (Fig 7) The condition is one of obstruction of the cystic duct, usually by calculi, with stasis of diseased bile in a contracted gall bladder over a long period of time, with precipitation from the mucus of the walls of the diseased gall bladder of calcium carbonate, which renders the bile opaque Usually some freely movable opaque bile is found, which will show a fluid level in the roentgenograms taken in the erect position In all four cases there were several calculi apparently impacted in the cystic duct These gall bladders are always small, the condition occurring only in small, chronically contracted gall bladders These have to be differentiated from calcific deposits in the gall-bladder walls (Fig 8) In these cases, there is no alteration in shape or density with change from horizontal to erect position, there being no opaque bile in these gall bladders Kornblum and Hall stress the following characteristic features of the condition

- (A) Suspect when gall bladder visualized without cholecystography
- (B) There is no change in the appearance after fatty meal
- (C) Persistence of gall-bladder shadow after cholecystography
- (D) Persistence of stones in the cystic duct with visualized gall bladder
- (E) Shadows unlike gallstones found in

association with a non-visualized gall bladder during cholecystography

SUMMARY

Technical considerations are outlined which afford maximum accuracy in cholecystography

The differential features of normal and pathologic gall bladders with or without calculi are described

The following conditions, now easily demonstrated by recent advances in cholecystography, are illustrated and briefly described, with differential diagnostic features (1) the normal gall bladder, (2) pathologic gall bladders, (3) cholelithiasis, (4) intra-hepatic gall bladder, (5) "Phrygian cap" gall bladder, (6) milk of calcium bile gall bladder

9 West 68th St

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as described by Ettinger (9) She reports three cases in which small concretions, not otherwise demonstrable, were detected

MILK OF CALCIUM BILE GALL BLADDER

Knowledge of new concepts of pathologic entities focuses attention on such condi-



Fig 8 Gall bladder with calcified walls

floating at a certain level within the bile. They are small cholesterol stones which float between biles of different concentrations at their interfaces. Through the courtesy of this author and the "American Journal of Roentgenology and Radium Therapy," one of the author's unmatched illustrations is reproduced herewith (Fig 6)

tions, with frequent surprises due to encountering them with fairly high incidence. This is true of the writer's experience with milk of calcium bile gall bladders. Although my personal experience with this condition has been quite limited, I recall seeing several of these cases in the past, yet did not recognize them as clinical entities. After reading the comprehensive descrip-

based on the maximum concentration observed rather than on any absolute numerical scale. Points on the curve (Fig 1)

tion must necessarily introduce errors into the measurements. The data, therefore, are presented only as a summary of aver-

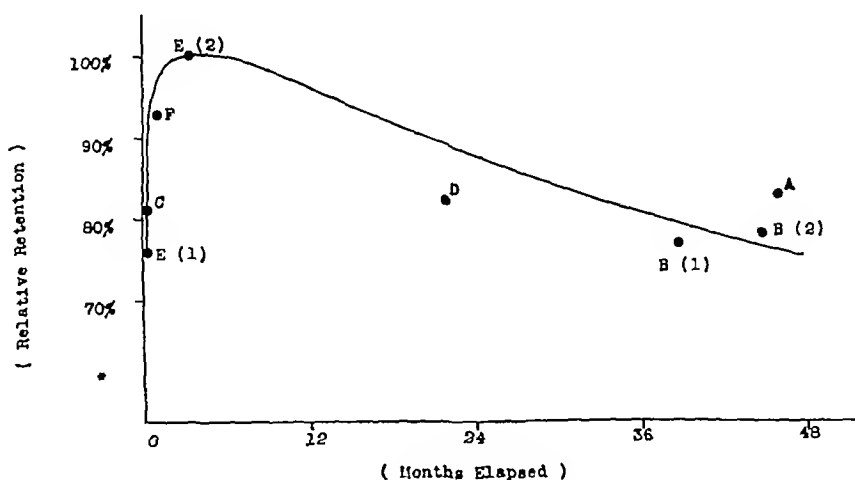


Fig 1 The retention of thorium dioxide by the reticulo-endothelial system

represent gamma-ray intensities relative to this maximum.

The apparatus employed in securing the clinical data was the "Gamma-ray Detector," previously described (3), with the addition of a watch-type integrating recorder (4), and an accurate automatic voltage regulator (5). The patients observed were routine diagnostic cases, taken at more or less random intervals after injection. It is obvious that individual variations in size and position of liver, thickness of abdominal walls, or slight differences in location of the Geiger counter relative to the patient under observa-

age conditions. The accuracy possible with successive readings on the same patient, a few minutes apart, has been found to be of the order of a few per cent.

The shape of the composite retention curve (Fig 1) indicates, in agreement with radiographic data, that a period of several days is required for the thorium to reach its maximum concentration in the region of the liver. In the course of subsequent readings, the observed radio-activity is found to decrease very gradually to approximately 80 per cent of this maximum value. Data now available do not extend beyond four years' history, but we

TABLE I

Patient	Date Injected	Date Checked	Time Elapsed	Total Count per Minute	Background Thorium Count per Minute	Retention Percentage
A	12/1/32	9/9/36	46 months	15.0	5.8	92
B (1)	8/16/33	11/17/36	39 months	14.2	5.7	85
B (2)	8/16/33	5/12/37	45 months	14.5	5.8	87
C	11/17/36	11/28/36	0.25 month	14.7	5.7	90
D	11/28/34	9/2/36	22 months	14.6	5.5	91
E (1)	7/8/36	7/14/36	0.25 month	14.1	5.7	84
E (2)	7/8/36	10/27/36	3.5 months	16.8	5.7	111
F	4/20/37	5/21/37	1 month	15.9	5.6	103

* The rate of concentration and subsequent elimination by the reticulo-endothelial system is shown on the graph of Figure 1.

THE RETENTION OF THORIUM DIOXIDE BY THE RETICULO- ENDOTHELIAL SYSTEM

By ROBERT J REEVES, M D , and J E MORGAN, PH D , Durham, N C

From the Department of Roentgenology of Duke Hospital

SINCE thorium dioxide solution was first used clinically by Radt (1), little has been learned about its rate of elimination from the body. We have been able to determine by roentgenograms that the liver and spleen retain some qualitatively large portion of the compound, but it is most logical that the radio-activity of the thorium series, which has engendered much of the prevalent suspicion of its physiological effects, should be chosen as an indicator for actual measurement of retention by the organism.

The Geiger-Muller counter offers a sufficiently sensitive, simple, and rapid method for measuring such small intensities of radiation directly from the patient. Experimental work was, therefore, undertaken with this type of instrument to determine the average retention of intravenously administered thorium dioxide in the human organism.

The absolute intensity of gamma radiation from fresh commercial thorotrast has been determined, in the course of our preliminary calibrations, to be equivalent to approximately 1.9×10^{-8} grams of radium per cubic centimeter. The factor is also substantiated by the recent work of Taft (2), whose measurements indicate a value of about 1.8×10^{-8} .

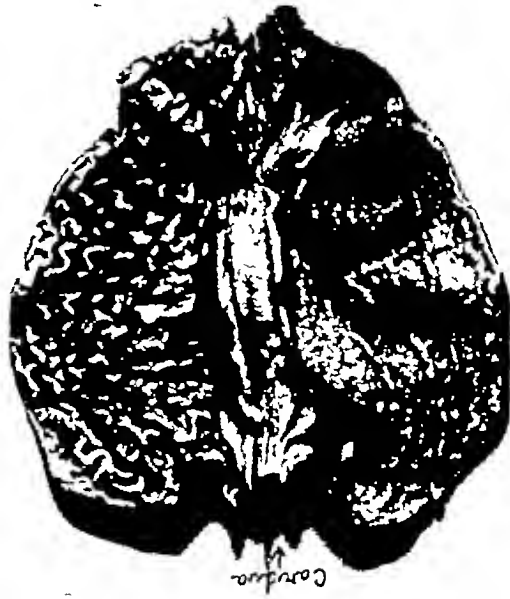
Although the radio-active life of thorium in equilibrium with its decay products is far too great to be a perceptible factor in a clinical investigation, it has been shown that thorium dioxide as prepared commercially from thorium nitrate originally includes none of the decay series except radiothorium. From this beginning, the decay of the relatively short-lived radiothorium together with the natural production of mesothorium will combine to cause a fairly rapid change in the alpha-ray activity of the sample. According to

the calculations of Schlundt¹ and others, the alpha radiation from a given sample of freshly prepared ThO_2 decreases by about half during the first five years, then gradually increases over a period of approximately thirty years to its original value.

During this time, the gamma radiation, however, undergoes a much smaller variation. This gamma radiation, being the only portion which can penetrate through the abdominal wall, will of course constitute the portion measurable by external apparatus. Unfortunately, complete parallel history of the gamma-ray activity of thorium dioxide solution *in vitro* was not possible, since the data herewith submitted include patients who received thorium injections two or three years before the beginning of the experiment. During the few months over which actual measurements have been taken, original ampules of the thorium solution have maintained their gamma-ray activity constant within the experimental errors of the original reading. Since the inherent difficulty of such work with living patients precludes any high degree of accuracy, we have for the sake of simplicity assumed the gamma-ray intensity of ThO_2 to be approximately constant over the four-year period covered by these data.

The next point of importance, then, is the establishment of some experimental basis for estimating the quantity of thorium retained by the patient after the useful, or diagnostic, service of the drug has been rendered. This is the purpose of the present work. The experimental results have been expressed as retention per cent (Table I), which values are arbitrarily

¹ Communication by courtesy of Heyden Chemical Corporation



Courtesy Am Jour Roentgenol and Rad Ther
Fig 1 The mucous membrane of a normal stomach (4)

by means of a leather belt under fluoroscopic control on a table similar to that used by Cole. The pressure technic (1, 9, 11) then came into more prominence. Regelsberger (13) employed umbrethor, a colloidal thorium dioxide, along with careful inflation, but this heavier metal was found to cause undesirable conditions such as clotting and formation of droplets. He pointed out, however, that were this technic successful, roentgenology would have a definite means of mucous membrane representation, with the possibility that the state of acidity based upon the structure of the markings could be judged. McKee (14) recently demonstrated ulcers in two cases with the gas-filled stomach alone. Poppel (15) used barium NaCO_3 and vichy water, while Arens and Meserow (16) made use of rugar and Seidlitz powders.

It must be admitted that in cases in which pressure was applied there has naturally been a certain amount of distortion, but in the main this method has offered many excellent contributions to the field of diagnosis.

We thus see that until now the pressure technic has commanded most of our atten-

METHOD OF PROCEDURE

tion and the intubation of air has been more or less neglected. In summing up the methods used directly to outline the mucosal folds, one realizes that too much inflation, or uncontrolled inflation, as well as too much pressure, may cause distortion. A technic which would properly incorporate both air and an opaque medium, and which would produce minimum distortion and be simple in execution, would therefore be desirable. To this end it occurred that the employment of a slightly greater amount than a minimum of barium and a lesser amount than a maximum of air could be utilized so as not to disturb the mucosal markings of the stomach. This might be supplemented by the utilization of radical changes in the position of the patient, so that the air and barium could be alternately displaced, and various portions of the stomach demonstrated in turn. This led to the adoption of the following technic

The patient having been instructed to present himself without breakfast is then intubated, and, with the end of the tube in the fundus of the stomach, about 50-100 c c of air are injected, depending upon the size of the stomach. Thus a moderate sized gas bubble is created. The patient is then given about four to six ounces of standard water barium meal. The usual roentgenographic and fluoroscopic studies are made in the erect posture. In the next step of the process we employ an adaptable fluoroscope, wherein a head and shoulder rest is used and foot straps are applied over the insteps. In this manner the patient can be kept in position with the least discomfort and can be rocked from a vertical position down to a Trendelenburg position of not less than forty-five degrees. Thus when the patient is placed in the Trendelenburg posture the air displaces the barium at the pylorus and the barium meal displaces the air at the fundus. With these moderate amounts of barium and air, and change of the position of the patient, both the upper and lower stomach may be studied separately. In rotating



Fig 2-A



Fig 2 B

Fig 2 The normal stomach (A) Upright position (B) Trendelenburg position showing the normal mucosal markings both in the proximal and distal portions of the stomach

the patient to the Trendelenburg posture, he is allowed to rest in the horizontal position for a minimum of fifteen minutes, to allow for dilution of gastric secretion and certain amount of cohesion of the barium to the stomach mucosa. A simple analogy in this respect would be a sealed milk bottle half filled. When the bottle is inverted the portion occupied by the fluid is displaced by air and a residual thin film of coating is left which takes several minutes to drain. The patient is filmed during this draining period. It is found that the barium becomes deposited in the rugal folds so that the markings are finely differentiated. The displacement process may be repeated under fluoroscopic control, and films taken with the tube under the table and the plate placed on the patient's abdomen. In this manner films are obtained showing the very fine mucosal markings which stand out in bold relief—their texture is so fine that frequently one must use a magnifying glass to observe their detail. Occasionally there is a normal gas bubble of sufficient size to carry out the study without the necessity of intubation.

Since the quantity of air intubated and

the amount of barium is dependent upon the size of the stomach and upon the patient's comfort, the problem of belching and untoward complications is eliminated.

The ordinary fluoroscope is not easily adaptable. With the old standard type and with shock-proof cable and tube the radical changes in position can be accomplished easily and efficiently.

One is cognizant of the fact that there never may be any one method of absolute standard procedure, but an attempt is made by this means to validate certain diagnostic criteria and effect a refinement in procedure which is easily applied. We believe that this technic accomplishes all of these aims.

Case 1 (Fig 2) E. D., 16 years of age, white, female, was referred with a history of pain in the epigastrium, bloating and nausea, marked constipation. The appetite was good. In this case 60 c.c. of air and 6 ounces of barium sulphate were intubated. The roentgen examination revealed a spastic colon with prolonged retention of the barium meal. No pathology was present.

Figure 2-A, taken in the upright posi-



Fig 3 Chronic hypertrophic gastritis (A, upper left) Erect (B, upper right) Prone (C, lower left) Supine (D, lower right) Trendelenburg Note hypertrophied rugae without scalloped margins

tion, shows the normal longitudinal rugal folds with the scalloped margins on the greater curvature. The upper part of the stomach is ballooned out down to about the sulcus angularis.

Figure 2-B was taken in the Trendelenburg position at about 55° . Note the replacement of the air in the antrum and pylorus without distention or ironing out of the mucosal markings. One may discern the clear-cut margins caused by the barium coating together with the prominent longitudinal folds on the anterior wall and the lesser longitudinal folds, with the mammulated appearance on the posterior wall as described by Forssell.

Case 2 (Fig 3) R S, female, 38 years of age, for ten years had complained of epigastric pain radiating to the back. The

pain was not related to the ingestion of food. The previous diagnoses had been periduodenitis and duodenal ulcer.

Gastric analysis showed increased free and total acidity, no blood in any of the specimens. Studies were made with intubation of 75 c.c. of air and 5 ounces of barium water. Exposures were made in the erect, prone, supine, and Trendelenburg 45° positions.

One can see the clear-cut marginal outlines and exaggerated longitudinal folds, both on the anterior and posterior walls. A striking feature is the absence of the scalloped appearance of the margins which has been considered evidence of hypertrophied rugae. This would indicate that scalloped margins are not always present in hypertrophy.



Fig 4-A

Fig 4-B

Fig 4 Diagnosis scirrhus carcinoma (A) Upright (B) Trendelenburg Note finely meshed honey-combed appearance of tumor

Following is the report of the gastroscopic study made by Dr Gabriel Tucker

"The esophagus was negative

"Examination of the stomach showed some thickening and increase in size of the rugal folds. The appearance was suggestive of a chronic hypertrophic gastritis. There were some features of the examination, however, that were unsuccessful because of the fact that the patient expelled the air from the stomach as rapidly as it was inflated. The pylorus was not satisfactorily examined."

Case 3 (Fig 4) S P F, 64 years of age, white, male, referred for "intestinal grippe" which had been present for six months. For the last seven weeks the patient had complained of loss of appetite, nausea, belching, with loss of 15 pounds in weight.

Exposures were made with intubation of 50 c c of air and 4 ounces of barium water in the upright (a) and Trendelenburg (b) positions. Diagnosis Scirrhus carcinoma, confirmed by operation and biopsy. Operation by Dr Williams, Abington Hospital.

Although the diagnosis could have been made from the ordinary films, the use of

the present technic allows us literally to visualize the morphologic changes. This may be of importance in helping to decide the advisability of operation in any particular case. It is also possible that various pathologic conditions may present different structural markings. Here the tumor shows a finely meshed, honey-combed appearance.

Case 4 (Fig 5) J L, white, male, 28 years of age. Symptoms: Chiefly neurologic tic, which had been present for two and a half years. Gastro-intestinal studies were made as part of a general examination. The patient had recently lost 14 pounds in weight. A film was taken with intubation of 60 c c of air and 5 ounces of barium in the Trendelenburg position; no pathology was found. The film is published in order to show the clear outline of the distal duodenum, which is ordinarily blotted out by the barium meal, while here it is silhouetted by the air in the stomach. Note that the scalloped margins are present, but that there are no hypertrophied rugæ.

Case 5 (Fig 6) R I. S. white, male,



Fig 5 Normal stomach with distal duodenum visualized through double contrast media

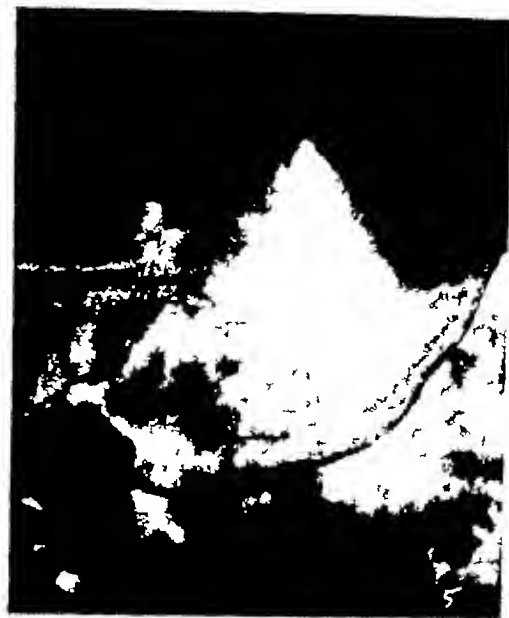


Fig 6 Trendelenburg position Normal mucosal markings obscured by presence of large amount of mucus

30 years of age Pain in the epigastrium with gnawing sensation for many years, no gas or belching, no relation of symptoms to meals The patient was generally weak and nervous

Gastric analysis Normal, free and total HCl, large amount of mucus Intubation of 75 c c of air with 6 ounces of barium

Here we note the obscuration of the mucosal markings as a result of the presence of mucus

A greater number of cases are being studied at present This preliminary report is presented so that other investigators may employ the technic and discover possible disadvantages or suggest constructive modifications, and by such contribution advance our skill in early and differential diagnosis of diseases of the stomach
Spruce Street Medical Building

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM¹

(Second Series, Fourth Installment)

By I S TROSTLER, M D, F A C R, F A C P, Chicago

MY OWN MALPRACTICE SUIT (THERE WAS NO
LIABILITY AND THE STATUTORY LIMITATION
HAD EXPIRED)

MIXING into and dabbling with so many malpractice suits, it would be more than strange if I should escape having one of those aggravating experiences myself. Running true to form and, according to the old song, "Everybody got one, and I got mine," I got mine.

While there is nothing of special importance about this suit, I will go considerably into detail so that those who have had no experience in this more or less delightful (?) diversion may know something of how a matter of this kind should be and usually is handled.

I treated a rather stout German woman, 41 years of age, for a simple hypertrophic goiter, which, because it almost completely surrounded her trachea—and she did not want it to be operated on—needed reduction in size. This occurred in 1918. Desiring to secure the promptest result in the shortest possible time, I gave the treatments with a short anode skin distance, as we were in the habit of doing in those days. In addition to the usual steadying and restraint by sand-bags, the patient was cautioned each time that she must not raise her head during the treatments. She had some difficulty in breathing unless her head was tilted slightly forward.

During the application of one of the treatments, I saw her raise her head several times, and at one time I shut off the current to caution her about this. About ten days later she developed a mild second degree dermatitis (only a few small blisters forming), which healed completely with-

out scarring, and did not interfere with the progress of her cure.

At the time that I discharged her, the thyroid had receded markedly in size, and she had no difficulty in breathing. We were on the best of terms, and she promised to pay me the balance of my fee which was still due. After waiting something over two years—for the statutory limitation to expire—for this balance, I demanded payment, and, failing to receive it after repeated duns, I placed the account with a collection agency which gets rough with recalcitrant debtors. Not receiving a reply to their invitation to pay, this agency threatened to sue for my fee, and within a few days I received a letter from an attorney, reading as follows:

"I have been retained by Mrs N—— H—— for the purpose of instituting suit against you by reason of malpractice on your part, whereby Mrs H—— suffered not only severe but almost fatal x-ray burns at your hands.

"I believe that this matter can be compromised if you see fit. Should I fail to hear from you promptly in reference to this matter, I will immediately institute legal proceedings against you to recover the damages she has sustained, so kindly govern yourself accordingly.

H—— G I—— "

I immediately notified my insurance carrier as follows: "Yesterday afternoon I received the following letter [quoting the foregoing letter *verbatim*].

"Let me know what, if any, reply I should make.

"As regards the status of this case. In the first place, I have had no dealings of any kind with this patient since May 22, 1919, at which time she received the last treatment from me and paid me \$20 on account. She did receive a very mild

¹ The Editor desires to state that much of the matter herein because quotations of court proceedings, has to be printed in form as received without normal punctuation or phrasing.

second degree roentgen dermatitis, as the result of a treatment administered by me on Nov 11, 1918. She owes me a balance of \$20 (her total fee was \$200), and a short time ago I placed the account with a collector. This firm threatened suit, and this threat of suit against me is the result of my trying to collect the balance.

"If I understand things correctly, the limitation has expired as far as a suit in tort is concerned, it being more than three years since the acts on my part which caused the alleged injury and over two years and nine months since I have seen her or administered any treatment of any kind."

In a very few days, I had the following letter from the law department of my insurance carrier:

"Your communication of the 11th instant with copy of letter addressed to you from H— G I—, lawyer, of Chicago, is acknowledged, and we would suggest the following reply:

"H— G I—, etc, I beg to acknowledge receipt of your communication of the 8th instant presenting an alleged claim of Mrs N— H—

"In order that I might locate my records of the treatment rendered this patient I would be pleased to have you advise me when Mrs H— consulted me, and the purpose, and advise me fully as to the number of treatments rendered to this patient.

"I would also be pleased to have your opinion as to my liability and her present condition.

"Thanking you for the courtesy of a reply, I am, etc

"Respectfully _____,"

"As suggested, write and mail the above letter to the attorney, and in the event of a reply forward same to us, retaining a copy for your records.

"At your convenience, complete the enclosed interrogatories and return.

"You are correct in your understanding that the two years' statute of Illinois applies to action of malpractice.

"Awaiting your advice, we are," etc

I immediately wrote the above suggested letter to the attorney, and filled out the insurance company's questionnaire as follows:

(Answers only are given, for brevity.)

"1 I S Trostler, 25 E Washington St., Chicago, Ill., College of Medicine, University of Nebraska, 1904. General radiology. Member of Chicago and Illinois State Medical Societies, Fellow A M A and American College of Physicians, member of the Radiological Society of North America, Chicago Roentgen Society, the Roentgen Society, London, Eng., German Medical Society of Chicago, honorary member of several medical societies, etc.

"2 Mrs N— H—, — M— Ave., Chicago. Housewife, married, age 44 years.

"3 She was treated for retro-laryngeal goiter of simple hypertrophic type, which was causing difficulty in breathing, cough, etc. I first saw her May 18, 1918, and began treatment June 6, 1918.

"When last seen by me, on May 22, 1919, her condition was *very much* improved, so much so that she and I agreed that she would need no more treatment.

"4 June 6, 1918, I gave 6 ma, 12-in anode skin distance, 7-in spark gap, through 3 mm of aluminium and 5 mm of sole leather filters for 6 minutes, using a broad focus, Universal type Coolidge tube, applied to the anterior surface of the neck. June 22, 1918, I applied the same except that I used 4 mm of aluminium filter (instead of 3). Ten days later (on July 2, 1918) a dermatitis appeared in the area treated, which developed into a mild second degree roentgen dermatitis, with a few small blisters forming, and which was entirely healed Nov 11, 1918.

"The urgency of her condition materially subsided, so no x-ray treatment was administered until after healing of the dermatitis. X-ray treatment was resumed Dec 5, 1918, with 5 mm aluminium filtration (instead of 3), and three areas were treated, avoiding the area of

the former dermatitis Procedure on Jan 2, 1919, same except only two areas treated, Jan 29, same except 4 mm aluminium filter used and four areas treated, Feb 27, 1919, same only three areas, March 27, 1919, same, April 24, 1919, same only 6 mm aluminium filter and two areas, and May 22, 1919, 5 mm aluminium filtration to two areas

"Frequent dressings to the area of dermatitis were applied between July 2, 1918, and Nov 11, 1918

"5 Not a fracture case

"6 X-ray examinations were made by me May 18, 1918 These showed the trachea to be compressed by the thyroid gland

"7 X-ray dermatitis appeared July 2, 1918, as a typical dermatitis, with redness, itching, stinging, slight swelling, and progression to the formation of several blebs (blisters), and later an ulcer, about two inches by three inches (from above downward) in size, roughly square in form This healed slowly, under sterile dressings, so that after about four and one-half months there was a clear healed surface with very little scarring, all of which disappeared in four months

"The apparatus used was a Victor Peerless transformer outfit, with auto-transformer and rheostat controls of the most approved type, with Coolidge tube, transformer and control Other particulars are given in reply to Question Number 4

"Rontgen dermatitis was due entirely to patient having raised her head and consequently shortened (or reduced) the target (anode) skin distance from 12 inches to somewhat less than 10 inches, for a considerable part of the time during the second (June 22, 1918) treatment She was receiving as much as her skin would tolerate with safety, so as to secure the utmost benefit from the treatment in the least possible time, and this apparently slight derangement or disarrangement of conditions caused her to receive an excessive amount of x-rays, the dermatitis resulting therefrom Her skin is very susceptible to x-rays, and the difference between the

twelve-inch anode skin distance and the less than ten-inch anode skin distance was sufficient to produce the skin injury The dosage delivered at ten inches from the target of the tube is something like one and one-third times that delivered at twelve-inch target skin distance, and when, as in this instance, the distance was less than ten inches some of the time, and the margin of safety was so small, because of the urgency of the case, the difference in the dosage delivered was more than the skin could tolerate

"Understand me, I am not trying to give an excuse, but merely stating facts, provable by expert witnesses

"8 Not treated before for the goiter, but had had treatment for bronchitis, etc, which was apparently caused by the pressure, her excessive weight, etc I do not know what she received, but she assured me that she was not benefited by the previous treatment She was referred to me for x-ray examination of her thorax and neck by Dr B F M—I made the examinations and reported the results to him, whereupon he sent her to me for x-ray treatment for the enlarged thyroid This physician and I are very friendly

"9 On March 9, 1922, I received a letter from H G I—, dated March 8, 1922, which I copied and sent to you and which contains all that I know of her claims "

(Questions and answers Numbers 10 and 11 are omitted, as unimportant)

"12 Services were administered while patient was in hospital, she coming there each time for treatment, except for dressings, during the period of the dermatitis, when they were applied at my office at 615 Garfield Avenue I owned the x-ray plant, the same not being the property of the hospital, operated it as the x-ray department of the hospital, collected all the fees, and the conduct and management of that department was in no way connected with the hospital or its management, nor was the patient in any way a hospital patient

"13 Patient (or her husband) owes me a

balance of \$20 Knowing the possibility of their making claim of malpractice I did not push this claim very hard until limitation for tort had expired After the expiration of two and one-half years, debtor not responding to duns, I placed the bill in hands of a collection agency which notified the patient that unless the claim was settled they would bring suit I have directed this agency to hold off any further action "

In due time I received acknowledgment of the foregoing statement, with assurance that, "There is nothing for you to do except to await developments or the initial move on the part of the claimant, or her attorney We want to assure you that the matter will be kept well in hand by us and that we will do everything within our power to prevent suit, but if our efforts are unavailing, and suit is filed, notify us immediately and forward all papers served on you "

About one month later I had occasion to write the following to the insurance company "I wrote to Mr H G I—as per the copy you sent me To-day (after one month and two days) he called me over the telephone and asked me to make an appointment, either at his office or mine, so that we could talk the matter over

"I asked him to allow me one week's time as I was very busy and wanted to consult my attorneys He agreed to this, saying that he intended to bring action if I did not arrange a satisfactory settlement He also mentioned that the limitation, which I seemed to think had expired, had not as far as this case was concerned—that it would not expire until it was known what the outcome of the case would be

"Please inform me what I should do in the matter "

A few days later, I received the following

"*In re H— vs Trostler*, File 11470

" , and we note that Mr I— is awaiting advice from you

"We suggest that you have Mr I— come to your office and have him advise

you fully of the claims of Mrs H— and especially ask him to cite you authority sustaining his position that this suit is not outlawed You might state to Mr I— that your treatment at the time was proper and was in accordance with the science of radiology as known in the year of 1918, and that if a burn did follow, it was not due to negligence or lack of skill on your part, or to anything omitted to be done by you in the treatment of Mrs H— You could further advise Mr I— that your attorney has advised you that the action is outlawed and that under all circumstances you have no settlement to offer

"Mr I— undoubtedly realizes that the action is outlawed and will, of course, make every effort to compromise the case with you

"We shall await your advice in the premises "

After receipt of the foregoing, I tried to get in telephonic communication with the lawyer, but failing to do so, I wrote "As *per* agreement, I called you up to-day (after conferring with my attorney), but you were out I left my telephone number for you to call me, but have failed to hear from you

"If you care to have a conference with me, and will call me by telephone, I will be glad to arrange for some satisfactory time that you can meet me in my office "

We arranged for a conference in my office, which occurred without any fruitful or definite conclusions I concluded that he was bluffing

Several months passed without any further developments At that time the insurance company wrote me

"*Re H— vs Trostler*, File 11470

"Relative to the above entitled matter, we would be pleased to know whether or not you have heard anything further from Mrs H— or anyone in her behalf concerning suit

"If no developments have occurred herein, we do not believe that action will be taken by Mrs H— At all events, any action at this time would be outlawed

"We are of the opinion that we can dispose of this matter in our records, but before taking this step we would appreciate your report together with your advice as to whether or not the matter was handled by us in a manner that would merit your approval. Such was our endeavor and we are only hopeful that we have succeeded in that behalf, but upon this point we shall await your advice.

"It is understood, of course, that in the event we do dispose of the file at this time, the same will be reopened in the event any action is taken by Mrs. H—

"Awaiting your reply," etc

After the lapse of about ten months following the conference between Mr. I—, attorney for Mrs. H—, I was called over the telephone by the attorney, and I at that time informed him that I knew that he was aware that he had no case, that the cause, if any had ever existed, was outlawed by the statute of limitations, and that I did not care to waste any more time on the matter. He said that he would submit a proposition to me, and I agreed to consider it. In a few days I received the following communication, dated Feb. 23, 1923:

"In accordance with conversations of recent date, I am submitting for final and immediate consideration by you, the proposition that the claim of Mrs. N— H— of this city against yourself, be put to a board of arbitrators, as previously outlined, namely: One doctor to be chosen by you, one doctor to be chosen by Mrs. H—, and the two arbitrators thus appointed to select a third, a licensed, practising attorney-at-law and admitted to the Supreme Court of the State of Illinois, to hear and determine the amount of damages Mrs. H— is entitled to by reason of the X-ray burns inflicted upon her at some date last past, the reasonable costs of the proceedings to be borne as follows: You to bear the expense of your arbitrator, Mrs. H— to bear the expense of her arbitrator, and the expense of the third arbitrator to be prorated between yourself and Mrs. H—, the arbitrators to return a finding or award

upon the hearing of all the evidence, according to the law, both statutory and common, in reference to arbitration and award, in the State of Illinois. I shall require a definite answer on this by Monday, Feb. 26, 1923, and upon your failure to acquiesce therein, I propose without delay to take such steps in the premises as I may deem expedient and advisable, of which you are undoubtedly informed at this time. This matter has dragged entirely too long and the censure which I have received at the hands of my client for the delay is well merited.

"Very truly yours,

"H— G I—"

I immediately wrote the insurance company as follows: "On February 1st, pursuant to a telephone appointment, Mr. I—, attorney for Mrs. H—, called upon me and informed me that Mrs. N— H— claimed that I had damaged her, etc. He further said that he and his client were willing to submit to arbitration in the matter and agreed to send me a letter outlining the details of such arbitration, within a few days.

"I informed him—as directed in your letter of April 18, 1922—that my 'treatment at the time was proper and in accord with the science of radiology, as known in the year 1918, and if any injury resulted, it was not due to negligence or lack of skill on my part or to anything omitted to be done in the treatment of Mrs. H—.' I also told Mr. I— that my attorneys inform me that the action is outlawed.

"His reply to the above was that he was connected with two other cases, which, if this case was not settled, would bring joint action against me. This latter was said in the tone of voice that he is in the habit of using—that of a big, blustering, and bombastic bluffer. I have not the least idea what or whom he refers to and am not worrying at all about his remark, but I mention it so that you may know about it.

"I heard nothing further from this attorney until to-day, when I received in the mail, the letter of which the attached is an exact copy. I have not made reply to

this, even though he insists upon my answer by Feb 26, 1923 Let me know what, if any, reply I should make, or take up the matter with him direct if you deem it best " I sent a *verbatim* copy of the letter from Mr I— relative to arbitration, along with foregoing

By return mail, came the following from the insurance company

"*In re H— vs Trostler*, File 11470

"Your communication of the 24th instant together with letter dated February 23rd, addressed to yourself from Mr I— is acknowledged We suggest the following reply to Mr I—

"I have your letter of the 23rd with reference to alleged claim of your client Mrs N— H— I note your proposal that this matter be submitted to a Board of Arbitrators After carefully reviewing my treatment, I am confident that what I did was proper under the circumstances and is exactly the treatment that should have been rendered at the time I am in a position to vindicate this treatment if necessary, and for that reason I am of the opinion that there is nothing to arbitrate so far as I am concerned

"For your information, you are advised that services were rendered to Mrs H— from June, 1918, to and including May, 1919 Mrs H— has allowed practically four years to lapse before coming to realize that she had been previously injured It is a matter of common knowledge that if any injury was occasioned by the x-ray, it would not have taken four years for that condition to manifest itself The claims of your client, therefore, are absurd in the light of scientific knowledge

"While I would dislike very much to be subjected to a malpractice suit, I nevertheless will not enter into any compromise or agreement to arbitrate a matter where no merit exists, nor shall I enter into any settlement, thus confessing a liability that does not exist If your client feels that she has any meritorious claim against me, she may proceed as she deems expedient

"I am confident that if you will investigate the matter, you will take no action

"Assuring you of my appreciation of your courtesies, I am," etc

According to instructions, I wrote to attorney I— as above and in three months received a summons and notice of suit for \$15,000 damages The charge was trespass This I immediately transmitted to the insurance company, at the same time notifying the Chairman of the Medical-legal Committee of the Illinois State Medical Society (from which I received a voluminous information blank to fill out) The attorney for the insurance company who had been handling this affair, immediately wrote me "We have your letter of the 9th instant together with the summons in the above action for acknowledgment The summons has been forwarded to Mr E— W R—, 105 S LaSalle St, your city, who will enter his appearance for you and will proceed to the defense of the case for you on our behalf

"We suggest that you arrange with Mr R— for a conference, advising us that you have done this

"It occurs to us that this action is outlawed although this question can be determined after we review the declaration filed against you "

Accompanying the information blank from the attorney of the Illinois State Medical Society I received the following

"*Re Malpractice Suit*—I am advised by Dr C B K— that a suit has been begun against you for alleged burns, and that you have sent the summons to the insurance company I have talked to their attorney regarding it, and judge from what he says that this lawsuit should not give you much concern

"I enclose one of our usual information blanks and ask that you kindly fill in the information requested at your early convenience and return to me I shall then be glad to co-operate with the insurance company in the active defense of the suit
R— J F— "

Under date of June 19, 1923, Mr F—, the attorney for the Illinois State Medical Society, wrote me

"*Re H— vs Trostler*—The complaint or

declaration in this case has now been filed, and I judge that they have the year incorrectly stated

"Will you please check your records again to be certain about them as this will be quite important. They allege that you were employed about June 6, 1922, and treated the woman after that time."

At the time the foregoing letter was sent to my office, I was with the Radiological Society party, en route to the Mid-annual meeting at San Francisco, and received it there. I immediately telegraphed "Dates given in my report of H— case are correct. I was no longer at St. Joseph's Hospital, where all treatments were administered to Mrs. H—, in 1922. I left that hospital Aug. 1, 1920, moving to my private offices at 25 East Washington Street. Date in plaintiff's declaration is wrong."

Mr. F— immediately replied "I thank you for your wire advising that the dates in your report of the H— case are correct. Having that in mind, you will not need to worry about this lawsuit."

I heard nothing further from this affair until Nov. 30, 1924, when after another lapse of over seventeen months, I received the following from R— J. F—, attorney for the Illinois State Medical Society:

"*Re H— vs. Trostler*—Mr. R— and I were in court on this case to-day and succeeded in getting judgment on the pleadings in your favor. The plaintiff prayed an appeal, but I am certain it will never be perfected, so to-day ends the celebrated case of N— H—."

"With congratulations on your being through with this, without the necessity of a trial, I remain, "

Two days later I had the following from the insurance company: "We are advised by our Mr. R— that he has finally disposed of the case against you on the pleadings."

"It is the disposition of this company to meet the full expectations of our contract holders in every instance in which we have the opportunity to serve them. It is our hope that we have met your expectation."

We would be pleased to hear from you in this connection and to know whether or not the service which we endeavored to render in this case has met with your approval."

(The phrase "the pleading," in the two foregoing letters, refers to the defense pleaded that the statute of limitations had lapsed and expired. This was deemed to be the shortest, easiest, and most direct way out, and was stressed by both attorneys in my behalf.)

Thus ended the only case in malpractice that has ever been filed against me, but I have my fingers crossed, my tongue in my left cheek, and I am knocking wood, as I write this. While the recitation of this suit may seem to be prolix and unnecessarily detailed, it is my desire to indicate the extreme importance of detailed reports to the insurance carrier and the State society's attorneys or committees, in the first place, and how very important are the records in every case, and of nature must be, so that these reports may be correct and detailed. It is important that he who is threatened with suit immediately notify his insurance carrier, but in my opinion, it is not so immediately necessary to inform the State society when suit is *only threatened*. In fact, I do not believe that they ask for such information. It is the business and duty of the insurance carriers, if, as, or when suit is threatened, to direct you so that the threat does not materialize into the filing of a suit, and, as a matter of fact, that is more a part of their service than many of us realize. I have said many times that the best way to defeat a malpractice suit is not to be sued. This is much more a truism than it is an aphorism.

Another of the lessons it is desired to drive home is that *not one word of admission of liability must be made*, and it is far better—under any circumstances—not to assume even the responsibility of answering the simplest questions, if we are not absolutely certain what the legal construction of the matter is or might be. In this case, the lawyer for the plaintiff tried to trap me into agreeing to arbitrate, thus admitting that

there might be some liability That is only one of the scheming traps that shrewd lawyers use or try to use There are many of these, some of which are applicable at one time, while others are best used "elsewhere and to-morrow" It has always been my dictum, and I have repeatedly advised men who have insurance, to secure the advice of the insurance carrier, advancing such of their own observations as in their opinion might be of aid and assistance, but being guided entirely by what the more experienced, trained defense attorneys suggest or advise I did this because I had reason to believe that the company in which I carried my protection knew best how to handle the situation If I had not had that confidence I would not have been paying the premium for their contract I bought what I thought was the best, just as I buy a certain kind of x-ray film or fountain pen Having used or known something about malpractice insurance, x-ray films, and fountain pens, because of quite a few years in the practice of medicine, I selected the kind I wanted, and used it according to directions with satisfactory results

RESUMÉ

After presenting the final paper of this series I feel that a brief summary will explain why it seemed suitable to add "Some of the Lessons to be Learned" to the title of this series It is, of course, understood that I have been trying to teach something of legal medicine to my readers

It has been said that "proof of the pudding is the eating thereof", but in my opinion, this saying or maxim is only half true if applied to this series of papers Though my readers have read what I presented—eaten the pudding—unless they profit by what they have read—digested and assimilated the pudding—they will not be benefited as I had hoped they would be

It has been my purpose to purvey mental food to the readers, and if they have read, thought about, and *made theirs* whatever they deemed to be of sufficient value or use, from what has been presented, it is my sincere hope that they have received and acquired the mental nourishment that has been the purpose and aim of the purveyor If I have been able to present a single thought that helped prevent or forestall one malpractice suit or save one moment of embarrassment upon the witness stand I will feel amply repaid for the time and effort expended

Having opened this series with a quotation from the Gospel of St Luke, I trust that I may be pardoned when, in closing, I quote from "The Great Emancipator" and say, in all sincerity, "I do the very best I know how, the very best I can, and I mean to keep doing so until the end If the end brings me out all right, what is said against me won't amount to anything If the end brings me out wrong, ten angels swearing I was right would make no difference" *What a splendid addition that would make to our Oath of Hippocrates*

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALENDAR

Meetings Falling Between the Dates of November 15 and December 31

November 20 Texas Radiological Society annual meeting at the Adolphus Hotel, Dallas, Texas

Editor's Note—Will secretaries of societies please cooperate with the Editor by supplying him with information for this page

CALIFORNIA

California Medical Association, Section on Radiology—Chairman, John D. Lawson, M.D., 1306 California State Bldg., Sacramento, Secretary, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles. Meets annually with California Medical Association

Los Angeles County Medical Association Radiological Section—President, D. R. McColl, M.D., Vice-president John F. Chapman, M.D., Secretary, E. N. Liljedahl, M.D., Treasurer, Henry Snure, M.D. Meets every second Wednesday of month at County Society Building

Pacific Roentgen Club—Chairman Raymond G. Taylor, M.D., 1212 Shatto St., Los Angeles, Secretary, L. Henry Garland, M.D., 450 Sutter St. San Francisco

COLORADO

Denver Radiological Club—President, W. Walter Wasson, M.D., 246 Metropolitan Bldg., Vice-president Ernst A. Schmidt, M.D., Colorado General Hospital, Secretary, Nathan B. Newcomer, M.D., 306 Republic Bldg., Treasurer, Leonard G. Crosby, M.D., 366 Metropolitan Bldg. Meets third Tuesday of each month at homes of members

CONNECTICUT

Connecticut State Medical Society, Section on Radiology—Chairman, Kenneth K. Kinney, M.D., 29 North Street Willimantic, Vice chairman, Francis M. Dunn, M.D., 100 State Street, New London, Secretary-Treasurer Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society

FLORIDA

Florida State Radiological Society—President, Gerald Raap, M.D., 168 S. E. First St., Miami, Vice president, H. O. Brown, M.D., 404 First Nat'l Bank Bldg., Tampa, Secretary-Treasurer, H. B. McEuen, M.D., 126 W. Adams St., Jacksonville

ILLINOIS

Chicago Roentgen Society—President, David S. Beilm, M.D., 411 Garfield Ave., Vice president, Chester J.

Challenger, M.D., 3117 Logan Blvd., Secretary-Treasurer, Roe J. Maier, M.D., 7752 Halsted St. Meets second Thursday of each month, September to May, except December

Illinois Radiological Society—President, Ivan Brouse, M.D., 316 W. State, Jacksonville, Vice-president, Cesar Gianturco, M.D., Carle Hospital Clinic, Urbana, Secretary-Treasurer, Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement

Illinois State Medical Society, Section of Radiology—President, Roswell T. Pettit, M.D., 728 Columbus St., Ottawa, Secretary, Ralph G. Willy, M.D., 1138 N. Leavitt St., Chicago

INDIANA

Indiana Roentgen Society—President, J. N. Collins, M.D., 23 E. Ohio St., Indianapolis, President-elect, Stanley Clark, M.D., 108 N. Main St., South Bend, Vice-president, Juan Rodriguez, M.D., 2903 Fairfield Ave. Fort Wayne, Secretary-Treasurer, Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May

IOWA

The Iowa X-ray Club—Holds luncheon and business meeting during annual session of Iowa State Medical Society

MAINE

See New England Roentgen Ray Society

MARYLAND

Baltimore City Medical Society, Radiological Section—Secretary, H. E. Wright, M.D., 101 W. Read St., Baltimore. Meetings each Monday night.

MASSACHUSETTS

See New England Roentgen Ray Society

MICHIGAN

Detroit X-ray and Radium Society—President, C. C. Birkelo, M.D., Herman Keifer Hospital, Vice-president, E. W. Hall, M.D., 10 Peterboro St., Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital. Meetings first Thursday of each month from October to May inclusive, at Wayne County Medical Society Bldg.

Michigan Association of Roentgenologists—President, J. C. Kenning, M.D., 1536 David Whitney Bldg., Detroit, Vice-president, A. W. Chase, M.D., 133 Toledo St., Adrian, Secretary-Treasurer, C. S. Davenport, M.D., 609 Carey St., Lansing

MINNESOTA

Minnesota Radiological Society—President, Walter H. Ude, M.D., 78 S. 9th St., Minneapolis, Vice-president, Leo G. Rigler, M.D., University Hospitals, Min-

neapolis, *Secretary Treasurer* Harry Weber, M D, 102 Second Ave S W Rochester Meetings quarterly

MISSOURI

The Kansas City Radiological Society—*President*, L G Allen, M D 907 N 7th St, Kansas City Mo, *Secretary*, Ira H Lockwood, M D 306 E 12th St., Kansas City, Mo Meetings last Thursday of each month

The St Louis Society of Radiologists—*President*, Joseph C Peden, M D, 634 N Grand Blvd, *Secretary*, W K Mueller, M D, 607 N Grand Blvd Meetings fourth Wednesday of each month

NEBRASKA

Nebraska Radiological Society—*President*, E W Rowe, M D, 128 N 13th St, Lincoln, *Secretary*, D Arnold Dowell M D, 117 S 17th St., Omaha Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island) *President*, Frank E Wheatley, M D, 520 Beacon St, Boston, *Secretary*, E C Vogt, M D, 300 Longwood Ave., Boston Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library

NEW HAMPSHIRE

See New England Roentgen Ray Society

NEW JERSEY

Radiological Society of New Jersey—*President*, J D Tidaback, M D, 382 Springfield, Summit, *Vice-president* Milton Friedman M D, Newark Beth Israel Hospital Newark, *Secretary*, P S Avery, M D 546 Central Ave Bound Brook Meetings at Atlantic City at time of State Medical Society and Midwinter in Newark as called by president

NEW YORK

Brooklyn Roentgen Society—*President*, Albert Voltz, M D, 115-120 Myrtle Avenue, Richmond Hill, *Vice president*, A L L Bell, M D, Long Island College Hospital, Henry, Pacific and Amity Sts, Brooklyn *Secretary-Treasurer* E Mendelson M D, 132 Parkside Ave Brooklyn Meetings first Tuesday in each month at place designated by president

Buffalo Radiological Society—*President* John Barnes, M D, 875 Lafayette Ave, *Vice-president* W L Mattick, M.D, 280 Highland Drive, *Secretary-Treasurer*, J S Gian-Franceschi M D, 610 Niagara Street Meetings second Monday evening each month.

Central New York Roentgen ray Society—*President*, W E Achilles M D 60 Seneca St. Geneva, *Vice-president*, M T Powers, M.D, 250 Genesee St, Utica, *Secretary-Treasurer*, Carlton F Potter, M D 425 Waverly Ave Syracuse Meetings held in

January, May, and October as called by Executive Committee.

Long Island Radiological Society—*President*, David E Ehrlich, M D, 27 W 86th St., New York City, *Vice-president* H Kouransky M D, 43-37 47th St., Long Island City *Secretary*, S Schenck, M D, 115 Eastern Parkway, Brooklyn, *Treasurer*, Moses Goodman, M D, 45-01 Skillman Ave, Long Island City Meetings third Thursday evening each month at Kings County Medical Bldg

New York Roentgen Society—*President*, E F Merrill, M D, 30 W 59th St., New York City, *Vice president*, I W Lewis, M D, *Secretary*, H K Taylor, M D, 667 Madison Ave New York City, *Treasurer*, R. D Duckworth, M D, 170 Maple Ave, White Plains Meetings third Monday evening each month at Academy of Medicine

Rochester Roentgen ray Society—*Chairman* Joseph H Green M D 277 Alexander St, *Secretary*, S C Davidson M D, 277 Alexander St Meetings at convenience of committee

Society of Radiological Economics of New York—*President*, Albert L Voltz M D, 115-120 Myrtle Ave, Richmond Hill, *Vice president*, M M Pomeranz M D, 911 Park Ave. New York City, *Secretary*, W F Francis, M D, *Treasurer*, Theodore West M D United Hospital Port Chester Meetings first Monday evening each month at McAlpin Hotel

NORTH CAROLINA

Radiological Society of North Carolina—*President*, Robert P Noble, M D, 127 W Hargett St Raleigh, *Vice president*, A L Daughtridge, M D 144 Coast Line St., Rocky Mount, *Secretary Treasurer*, Major I Fleming M D 404 Falls Road, Rocky Mount Meetings with State meeting in May, and meeting in October

OHIO

Cleveland Radiological Society—*President*, North W Shetter M D Lakewood City Hospital, Lakewood, *Vice president* John Heberding M D St. Elizabeth's Hospital Youngstown *Secretary Treasurer* Harry Hauser M D Cleveland City Hospital, Cleveland Meetings at 6 30 P.M. at Cleveland Chamber of Commerce Club on fourth Monday of each month from October to April inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists)—*President* George Benzing M D St. Elizabeth Hospital Covington Ky, *Secretary Treasurer*, Justin E McCarthy, M D, 707 Race St Cincinnati Ohio Meetings held third Tuesday of each month

PENNSYLVANIA

Pennsylvania Radiological Society—*President* Sydney J Hawley M D Geisinger Memorial Hospital

Danville, *First Vice president*, William J. McGregor, M D, 744 Franklin Ave., Wilkinsburg, *Second Vice-president*, Oscar M. Weaver, M D, 12 S. Main St., Lewistown, *Secretary-Treasurer*, Lloyd E. Wurster, M D, 416 Pine St., Williamsport, *President-elect*, Charles S. Caldwell, M D, 520 S. Aiken Ave., Pittsburgh. Annual meeting, May, 1938. Exact date and place to be decided.

Philadelphia Roentgen Ray Society—*President*, Thomas P. Laughery, M D, Germantown Hospital, *Vice president*, Elwood E. Downs, M D, Jeans Hospital, Fox Chase, *Secretary*, Barton H. Young, M D, Temple University Hospital, *Treasurer*, R. Manges Smith, M D, Jefferson Hospital. Meetings first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S. 22nd St., 8:15 P. M.

The Pittsburgh Roentgen Society—*President*, F. L. Schumacher, M D, Jenkins Arcade, *Secretary*, H. N. Mawhinney, M D, Mercy Hospital. Two Fall and two Spring meetings at time and place designated by president.

RHODE ISLAND

See New England Roentgen Ray Society

SOUTH CAROLINA

South Carolina X-ray Society—*President*, Robert B. Taft, M D, 105 Rutledge Ave., Charleston, *Secretary-Treasurer*, Hillyer Rudisill, M D, Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

Memphis Roentgen Club—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee State Radiological Society—*President*, H. S. Shoulders, M D, 246 Doctors Bldg., Nashville, *Vice-president*, S. S. Marchbanks, M D, 508 Medical Arts Bldg., Chattanooga, *Secretary-Treasurer*, Franklin B. Bogart, M D, 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

VERMONT

See New England Roentgen Ray Society

VIRGINIA

Radiological Society of Virginia—*President*, Fred M. Hodges, M D, 100 W. Franklin St., Richmond, *Vice president*, L. F. Magruder, M D, Raleigh and College Aves., Norfolk, *Secretary*, V. W. Archer, M D, University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society—*President*, H. E. Nichols, M D, Stimson Bldg., Seattle, *Secretary*, T. T. Dawson, M D, Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

NEWS ITEM

Section on Radiology of Connecticut State Medical Society met Sept. 22, 1937, at the New Haven Hospital. Dr. Bradley L. Coley, of the Memorial Hospital, New York City, spoke on "Diagnosis and Treatment of Bone Tumors in Children."

neapolis, *Secretary-Treasurer* Harry Weber, M D, 102 Second Ave, S W, Rochester Meetings quarterly

MISSOURI

The Kansas City Radiological Society—*President* L G Allen, M D, 907 N 7th St, Kansas City, Mo, *Secretary* Ira H Lockwood M D, 306 E 12th St, Kansas City, Mo Meetings last Thursday of each month

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PENNSYLVANIA

Pennsylvania Radiological Society—*President* Sydney J Hawley M D Geisinger Memorial Hospital

dye from the blood. Again the density of the bladder shadow is noted and further observation is made of the pelvis and ureters. The fourth film is made at the end of one hour. At this time the urinary tract usually will be practically free from dye and a conclusion of good total function may be made. If the kidneys are still well filled without an obstructive lesion after one hour, a further film may be made which will aid in determining the total renal function.

No compression or other interference with normal activity should be done except possibly a five-minute compression of the ureters before the fifteen-minute film is made or directly after this if a repeat film is indicated. To effect compression, two large rolls of bandage may be placed over the ureters at the pelvic brim and a compression band tightly applied.

When there is a question of retention in a ptosed kidney the patient should remain in the upright position and preferably walk about between the examinations. In the advent of a markedly ptosed kidney, either retention may be observed or poor function may indicate disturbance of circulation by rotation of the kidney pedicle, as described by Kimm and Smith.

Tuberculosis of the kidney may produce a very bizarre pattern. By the very nature of the disease, only a localized portion of the kidney may be affected and this may easily be mistaken for a calyx that is empty at the time of the examination. The presence of a large or small area of involvement may not be indicated at all by the function, extensive lesions may show fair function while small lesions may show poor function. Pus, blood, and clots may create any kind of visualization. Retrograde pyelography is most essential in the presence of a suspected renal tuberculosis in most cases.

Any type of visualization may also be expected in the presence of a renal tumor, depending on hemorrhage, pressure, renal destruction, and irritability of the kidney, thus making the diagnosis difficult in many cases. Here again retrograde examination will often be found essential.

Excretory urography constitutes an excellent method for the detection of calculous disease. However, there are many times when the findings are very difficult to interpret. Ureteral calculi, if they obstruct the ureter completely, may cause entire cessation of function in the corresponding kidney and no visualization will take place. Likewise, a stone in a calyx of the

kidney will obstruct an infundibulum and no visualization will occur. As a whole, however, in unilateral calculi much valuable information may be obtained regarding the sound kidney and a fair estimate of function may be determined in a kidney containing a calculus.

For the detection of anomalies of the kidneys and ureters, this method of examination is usually satisfactory.

When prostatic obstruction prevents the passage of the cystoscope, excretory urography many times is of great value, particularly in determining renal function together with dilatation of the kidneys and ureters. The presence of a high blood urea, however, will preclude the possibility of a satisfactory examination, and drainage, together with a large intake of water to reduce the blood urea, is necessary before a satisfactory examination can be made.

We have found that when a urogram is made following catheterization of the ureters, pseudo-retention will often be seen. Such an examination should not be made soon after catheterization of the ureter. The examination of patients with trauma to the urinary tract may be safely done by excretory urography and a definite diagnosis of a ruptured kidney or bladder may be established by visualization of the opaque medium outside the urinary tract.

The presence of a questionable lesion in a kidney following excretory urography should in most instances be checked by a retrograde pyelogram.

A final diagnosis in pathological lesions should be carefully correlated with kidney symptoms and consultations with an experienced urologist before any radical operative procedure is advised, as many pitfalls will be encountered in this method of examination of the urinary tract and these may only be avoided consistently by the experienced urologist. Only in this manner can the fullest value be obtained by excretory urography.

BERNARD H. NICHOLS, M.D.

COMMUNICATIONS

CANCER AID FOUNDATION

A charter has been issued to the Virginia Cancer Foundation, organized, according to its sponsors, to aid indigent victims of cancer in the State and to carry on cancer research. The Foundation was organized with no capital

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

EXCRETORY UROGRAPHY

Excretory urography has become one of the important methods of examination of the urinary tract, for this reason, it seems pertinent to evaluate its field of applicability and its limitations as a diagnostic procedure. It is simple to carry out and, wherever a roentgenologist has adequate facilities, is being used more and more frequently. At the same time, greater responsibility is placed on the radiologist for interpretation of a urogram with its diagnostic possibilities.

We should never forget the contribution of Rowntree who, in 1929, conceived the possibility of such a method of examination, making it pass from a dream to a reality, and of Binz, von Lichtenberg, and Swick who perfected the method. Previous to the publication of the work of these men, the practice of pyelography required the art of a urologist in all cases and most radiologists were quite dependent upon the urologists for interpretation. Now that excretory urography is widely practiced in small hospitals and in many places where a urologist is not available, grave responsibility is placed upon the radiologist, for which he should prepare himself by a careful analysis of all publications on this subject.

At the present time it would seem that perhaps the greatest value of excretory urography lies in determining the absence of pathological changes, thereby eliminating the urinary tract as the cause of symptoms. Perhaps next in importance is something which everyone doing this work has questioned—what is its value as a test of kidney function? This question has been studied by Braasch, who made a careful analysis of a series of 60 cases of various lesions of the urinary tract. By comparing the results secured by excretory urography with those secured by indigo carmine tests, he found that the two methods were of about equal value in 78 per cent of the cases, while in 22 per cent they were not in agreement. From a comparative check with other methods of testing the function and from autopsy findings, he concluded

that excretory urography gave a quite accurate test in the presence of hydronephrosis, pyelonephritis, polycystic kidney, and solitary cyst of the kidney. While it may often give inaccurate results in the presence of renal tuberculosis and calculous disease, Braasch adds that indigo carmine tests are also often inaccurate when these conditions are present, but the additional information gained by knowledge of an anatomical deformity may make up for the discrepancy.

We have found that it is most valuable to follow a routine method of examination in all cases if our diagnostic acumen and evaluation is to be of high quality.

In our routine the first film is made five minutes after the injection of the dye. At this time the interpretation of the appearance and density of both kidney pelves, ureters, and bladder are of most importance. The next film is made in fifteen minutes and at this time the best filling will usually be obtained. Again the density of the shadow within the kidneys and bladder are observed in order to estimate the function.

It should be possible also at this time to determine hypermotility if present, the kidneys remaining empty. If motility is normal, the kidneys will empty from a filled pelvis. When the emptying occurs rapidly, there may be only a fragmentary visualization of the pelvis and all available films will be necessary to secure a correct outline of the pelves and calices. However, even if the filling is not good, sufficient normal cupping of calices may be seen to rule out pathological change. Observation of the ureters at this time will often determine abnormality in dynamics. Frequently it is necessary to search all films to secure visualization of an entire ureter.

The third examination is made thirty minutes from the time of the introduction of the dye, fifteen minutes after the preceding film. At this time the kidney shadows will be more pale, showing the extent of elimination of the

Section C Dose or the Specification of the Conditions of Gamma-ray Treatments

6 The specification of the conditions of gamma-ray treatments should, where possible, include statements of—

- I *Quantity*—The total quantity of radiation (expressed in roentgens) estimated to have been received by the lesion
- II *Particulars of Radium Source*—(a) The total amount and nature of radio-active substance employed (expressed as equivalent mgm of radium element) (b) Type, number, and distribution of the containers (c) The material and thickness of filters and the nature of the material externally adjacent to the skin
- III *Technic*—(a) In the case of surface applicators or "large radium units," the quantity of radiation per field at the surface (b) The dosage rate during each individual irradiation (c) The total time over which a course of treatments is spread (d) The time intervals between successive irradiations (e) In the case of surface applicators or large radium units, the radium-skin distance (f) The number, dimensions, and situations of the ports of entry

Section D Instruments

7 The following types of apparatus are suggested as suitable for the measurement of quantity in roentgens

(a) *X-ray Primary Standards*—The free air chamber shall be used for free air measurements for all wave lengths down to the practical limit set by the consideration that the chamber must be of such width and length that the full ionization produced by the corpuscular emission from air is measured in accordance with the definition. An air-wall chamber which meets the requirements of the definition may be used for harder radiations

(b) *X-ray Practical Instruments*—The air-wall chamber may be used for clinical measurements of γ -ray quantity over the entire voltage range

(c) *Gamma-ray Standards and Practical Instruments*—The air-wall chamber may be used for the measurement of primary, scattered, or a combination of both radiations

8 Instruments used to measure radiation quantity or dosage may conveniently be called dosimeters and dosage-rate (or dose-rate)

meters, respectively, and shall be calibrated in roentgens or roentgens per minute

9 The calibration readings of dosimeters and dosage-rate meters should be independent of the wave length within the range for which they are designed or used

10 Dosimeters and dosage-rate meters should be provided with suitable arrangements (e.g., standard radium source, Bronson leak, or capacity sharing device) for checking the reproducibility of their readings

11 The calibrations of dosimeters or dosage-rate meters should be tested periodically by a recognized testing laboratory over the range of wave lengths for which they are designed or used

12 The National Standardization Laboratories shall be invited to undertake standard measurement and the calibration of dosimeters relative to all forms of radiation therapy to which these recommendations may apply. They shall also be invited to issue joint reports from time to time thereon

Section E Appendix

Note 1—Note that 0.001293 gram is the mass of 1 c.c. of dry atmospheric air at 0° C and 760 cm. of mercury pressure

Note 2—For example, in an hypothetical case of medium γ -rays,

The dose measured in air, D equals 300 r,

The dose measured at the surface, D_0 equals 500 r,

The dose measured at 1 cm. depth, D_x equals 200 r,

NB , D is not to be confused with the energy actually absorbed by the tissue

Section F Rules Governing the Selection and Work of the International Committee for Radiological Units

13 The International Committee on Radiological Units shall be governed by the following rules

(a) The International Committee on Radiological Units (ICRU) shall be composed of two representatives from each country sending delegates to the Congress. These representatives shall be chosen by the National Committee of Delegates for each country. However, any country having a National Standardization Laboratory may have three representatives, one of whom shall be appointed by such laboratory, but the representatives from a single country shall always include one radiologist and one physicist

stock and on a non-profit basis, "for the purpose of contributing such sums of money as the board of trustees may deem wise, and which the Foundation may possess in excess of its own requirements, to other institutions or individuals in the State of Virginia to be used under proper supervision exclusively for cancer research or for the diagnosis and treatment of indigent cancer patients"

"We hope," said Dr Wright Clarkson, of Petersburg, Va., director, "to have several million dollars on hand within about ten years. With whatever funds we may accumulate as we go along, we will do what we can for treatment of cancer victims in Virginia who are unable to pay, and we expect to contribute as best we can to organizations engaged in cancer research in the State"

Education of laymen in cancer prevention and early treatment, the Foundation will leave to organizations now engaged in that work

Men and women prominent throughout the State are officers. Dr J Shelton Horsley, Sr., of Richmond, is chairman of the research committee

tity of electricity of either sign (See Appendix, Note 1)

3 Measurements of radiation quantity shall be expressed in roentgens. Measurements of dosage rate shall be expressed in roentgens per minute

Section B Dose or the Specification of the Conditions of X-ray Treatment

4 In the description of the conditions of x-ray treatments, distinction shall be made between the quantity of radiation measured in air and the quantity of radiation estimated to have been received by the tissue. Since the symbol, r , is reserved for the unit, the amount of the dose may be designated by the letter D . The use of subscripts is suggested to distinguish dosage measurement made under different conditions, e.g., in free air— D , at the surface of the skin (including back-scatter)— D_0 , etc (See Appendix, Note 2)

5 The specifications of treatment conditions shall include the following

I *Quantity*—The quantity of radiation (expressed in roentgens) estimated to have been received by the lesion

II *Quality*—(a) The spectral energy distribution of x-radiation shall be designated by some suitable index, called quality. For most medical purposes it is sufficient to express the quality of the x-radiation by the half value layer in a suitable material. Up to 20 kv (peak) cellophane or cello, 20–120 kv (peak) aluminum, 120–400 kv (peak) copper, 400 kv up (peak) tin. For a more definite specification of the quality of the radiation the complete absorption curve in the same material is preferable. (b) Material and thickness of filter, including tube walls. (c) Target material

III *Technic*—(a) Total quantity of radiation per field (incident and emergent) received in an entire course of treatment. (b) Quantity of radiation per field measured at the surface (D_0) at each individual irradiation. (c) The dosage rate expressed in r/min during each individual irradiation. (d) The total time over which a course of treatments is spread. (e) The time interval between successive doses. (f) The target-skin distance. (g) The number, dimensions, and location of the ports of entry

RECOMMENDATIONS OF THE INTERNATIONAL COMMITTEE FOR RADIOLOGICAL UNITS (CHICAGO, 1937)

Introduction

Pursuant to the reference to gamma-ray dosage in the recommendations of the International Committee at its 1934 meeting at Zurich, it is now considered that sufficient evidence exists for the provisional adoption of a single unit, the roentgen, as the unit of quantity, not only for x-rays but also for gamma rays. To do this it is necessary to adopt a somewhat more generalized definition of the roentgen and this is given below. It is proposed that this definition be regarded as provisional and that a more exact definition to include all classes of radiation be prepared for the next Congress

Section A Units

1 The International Unit of *quantity* or *dose* of x-rays or gamma rays shall be called the "roentgen" and shall be designated by the symbol " r "

2 The roentgen shall be the quantity of γ - or gamma-radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying 1 e.s.u. of quan-



Grand Banquet, Fifth International Congress of Radiology Chicago

(b) The nominations of the above-named representatives of each country shall be communicated through the delegates of that country to the Secretary of the Executive Sub-committee of the International Committee on Radiological Units at least thirty months before the next Congress

(c) In case new representatives shall not have been appointed or their nominations not have been furnished within the time and in the manner above specified, the former representatives shall be retained and considered to have been re-appointed. In the event of a representative being unable to attend the I C R U meetings, a substitute may be appointed by the national delegation through its chairman. Similar substitute appointments may be made by the directors of the National Laboratories

(d) The continuance of the policies and records of the I C R U shall be in the hands of the standing Executive Sub-committee, consisting of six members elected by the I C R U from among the members of the whole Committee

(e) The members of the Executive Sub-committee shall be elected to serve for terms of nine years each. The two senior members shall automatically retire at the end of each Congress but shall be eligible for re-election. A meeting of the I C R U shall be called on the first day of Congress to fill any vacancies existing in the Executive Sub-committee

(f) The Executive Sub-committee of the I C R U shall elect its own Chairman and Secretary from among its members. The Secretary shall be custodian of all records and papers relating to the work of the Committee

(g) The Executive Sub-committee shall familiarize itself with the progress in the field of dosimetry and prepare the program to be submitted to the main Committee for discussion. A preliminary report thereon shall be published and circularized to all members of the I C R U at least six months before the meeting of the Congress. The final agenda for the meeting shall be prepared by the Executive Sub-committee on the first day of the Congress. The Executive Sub-committee shall report to the I C R U on all matters presented to it.

(h) Meetings of the I C R U shall be presided over by the Chairman, selected from the country in which the Congress is held. He shall be assisted, as may be necessary, by the Executive Sub-committee

(i) A résumé of any formal discussion pre-

sented at a meeting of the I C R U by any member must be submitted in writing by such member to the Secretary of the Executive Sub-committee before the same shall be accepted for inclusion in the minutes of the meeting

Members of the Sub-committee

H Behnken, *Chairman*, term, nine years,
L S Taylor, *Secretary*, term, nine years,
E Pugno-Vanoni, term, six years,
I Solomon, term, six years,
R Sievert, term, three years,
F L Hopwood, term, three years

Members of the International Committee for Radiological Units Preparing the Above Report

G Failla, *Honorary Chairman*, U S A ,
I Solomon, *Chairman*, France,
L S Taylor, *Secretary*, U S A ,
G Schwarz, Austria,
J Juul, Denmark,
H M Hansen, Denmark,
H Holthusen, Germany,
H Behnken, Germany,
W Friedrich, Germany,
F L Hopwood, Great Britain,
G W C Kaye, Great Britain,
N S Finzi, Great Britain,
A Lambadaries, Greece,
D den Hoed, Holland,
A Bouwers, Holland,
M Ponzio, Italy,
E Pugno-Vanoni, Italy,
M Tanaka, Japan,
K Inouye, Japan,
J Jovin, Roumania,
E C Ernst, U S A ,
R R Newell, U S A

FIFTH INTERNATIONAL CONGRESS OF RADIOLOGY

The Fifth International Congress of Radiology has passed into history, more fully reported by the lay press of the United States than have been any of its predecessors. For the first time, it would seem, the United States has become aware of what has been going on in this specialty of medicine. The country is becoming radiation-conscious, a condition which is bound to react to the advantage of those who have practised roentgen-ray diagnosis and radiation therapy through the introductory period

through such fundamental treatises as Davidoff and Dyke have presented that roentgenology can continue to progress in a sane and useful manner

This concise and timely contribution should have a prominent place on the reading shelf of all who are interested in the diagnosis of intracranial disease. It is hoped that in the near future these same authors will provide an equally informative text on the abnormal encephalogram

THE DIGESTIVE TRACT A Radiologic Study of the Anatomy, Physiology, and Pathology
By ALFRED E. BARCLAY, O B E, M A, M D (Cantab), D M R and E (Camb), M R C D, F A C R, Honorary Radiologist to the Nuffield Institute for Medical Research, Oxford, England. Second Edition. A volume of 427 pages. Published by The Cambridge University Press, London, and the Macmillan Company, New York, 1937. Price \$12.00

Four years ago the first edition of this text was widely acclaimed by physicians throughout the world. This new edition brings the book abreast of the latest research. It has been entirely reset and many additions and changes have been made. In its present form it constitutes the most comprehensive up-to-date radiologic text concerning the alimentary tract in the English language.

The volume is a summarization of the acquired experience of a quarter of a century in the fluoroscopic and radiographic examination of the alimentary tract. The first part of the book is devoted to technic and a comprehensive consideration of the normal anatomy and physiology of the gastro-intestinal tract. This reflects the author's belief that there is one and only one safe guide to radiologic interpretation and that is a knowledge of the normal.

The author's discussion of the technic of fluoroscopic palpation is the best that has appeared in any text-book and reflects his ability and command of this most valuable procedure. In Barclay's opinion radioscopy is the greatest ally that we have in detecting the finer pathologic changes in the stomach and other organs and is essential for revealing the contour of the folds of the mucous membrane in which small pathologic lesions may be tucked away. He believes that it is doubtful if the

value of this intricate procedure is even fully appreciated by the majority of workers.

The chapter devoted to lesions of the colon is succinct but somewhat brief compared to the importance of the subject. The author apparently is not convinced of the value of the radiologic examination in cases of colitis, for he states that he is very skeptical of the radiological and clinical diagnosis of colitis. American observers will challenge this viewpoint.

In a chapter written in collaboration with Dr L. A. Rowden, the anatomy, physiology, and pathology of the gall bladder are considered, together with the details of the roentgenologic examination and the interpretation of the roentgenologic findings.

Seven appendices of interest to general radiologists are included in the present volume. The second of these, dealing with the radiation risks of the roentgenologist, should be read by all physicians undertaking x-ray examinations, especially non-radiologists.

This text-book should have a wide appeal to students, physicians, and all radiologists who are interested in an intelligent roentgenologic examination of the alimentary tract.

AMERICAN MEDICINE Expert Testimony Out of Court. Two volumes, 1,500 pages. Edited and published by The American Foundation, 565 Fifth Avenue, New York City. Price \$3.50.

The title should be International Medicine, because the problems pertaining to American Medicine are universal in scope and the matter contained in these two volumes can truly be applied to other nations, probably in a varied form, but in spite of modifications the basic principles involved are identical.

The two volumes contain excerpts from approximately five thousand letters, written by some twenty-one hundred physicians, each one of whom received a letter asking him to express an opinion as to the solution of the socioeconomic problems confronting medicine.

The initial letter addressed to these contributors stated that the Foundation had little faith in the effectiveness of questionnaires, therefore, each one was requested to write an extensive treatise according to his own inclinations, without restriction or instruction. Also, the original request had a ring of sincerity and personal appeal which was carried throughout the entire correspondence—there was nothing

To those who participated in or attended the Congress, no brief résumé of its activities and results is adequate. Figures alone cannot tell the story in the practices of radiologists will its results be recorded. While the management, under the leadership of President Arthur C. Christie, M.D., and General Secretary B. H. Orndoff, M.D., was masterful and effective, it took more than was possible in these councils to secure the result. The manner in which the presentations of scientific contributions was conducted, the international influence of the projections in several languages, the wide range of the exhibits, the effective publicity, the careful management of the social aspects of the Congress, all resulted from the farseeing plans of the committees. Many small group gatherings made possible a degree of acquaintanceship and an exchange of ideas between radiologists of widely separated countries.

The Sixth International Congress of Radiology is planned to be held in 1940 in Berlin. As each Congress learns from its predecessor, the radiologists of the world will look to that event as a further step in progress.

COLORADO STATE MEDICAL SOCIETY

The Board of Trustees of the Colorado State Medical Society have chosen the dates, Wednesday afternoon to Saturday night, inclusive, September 7, 8, 9, and 10, 1938, as the dates for the sixty-eighth Annual Session of the Colorado State Medical Society, to be held at the Stanley Hotel, Estes Park, Colorado.

These dates were selected following receipt of communications from a large number of medical organizations which indicated these dates would cause the least possible amount of conflict with such other meetings as have been so far definitely scheduled for September, 1938.

A MEMBER HONORED BY STATE SOCIETY

E. M. Van Buskirk, M.D., of Fort Wayne, was made president-elect of the Indiana State Medical Association at the annual meeting of the organization held at French Lick, October 4-6. Dr. Van Buskirk will serve as president in 1939.

BOOK REVIEWS

THE NORMAL ENCEPHALOGRAM By LEO M. DAVIDOFF, M.D., Assistant Professor of Neurology in the College of Physicians and Surgeons, Columbia University, Attending Neurological Surgeon to the Neurological Institute of New York, and CORNELIUS G. DYKE, M.D., Assistant Professor of Radiology in the College of Physicians and Surgeons, Columbia University, Assistant Director in the Department of Radiology of the Neurological Institute of New York. A volume of 224 pages. Published by Lea & Febiger, Philadelphia, 1937. Price \$5.50.

Since the use of encephalography was re-introduced in 1921, much has appeared in the literature concerning the use of this procedure in the diagnosis of intracranial disease. Many of the disappointments and much of the criticism that have arisen from the use of this method of examination have been due more to a lack of knowledge concerning the fundamental principles of its use than to any fault of the procedure itself. The interpretation of the resulting films requires not only a familiarity with roentgenography generally, and cranial roentgenography in particular, but a thorough knowledge of the anatomy of the brain and the physiology of the cerebrospinal fluid circulation. Over a number of years the authors have emphasized in their writings the importance of a detailed knowledge of the normal intracranial contents as seen in the encephalogram as a basis for diagnosis of pathological conditions by this method. The object of this book is to present a fundamental thesis on encephalography based not only on the authors' experience with 4,000 cases, but also a review of the literature. The material covered includes a description of the technique, indications, and contra-indications for the performance of the test and the reaction of the patient during and after the procedure. The body of the book is concerned with what might be termed the encephalographic anatomy of the living brain and its coverings viewed by means of the contrasting shadows of tissues and gas in the stereoscopic roentgenogram.

The authors have carried to perfection a radiological monograph that might well be used as an example for consideration of other anatomical structures. Certainly in the past roentgenologic diagnosis has suffered because of an inadequate understanding of the normal on the part of many observers, and it is only

snapping hip, and arthritis deformans of the hip. All of these subjects are excellently portrayed, both as to etiologic factors involved and as to the more modern methods of treatment.

In the same volume is found a discussion of the various lesions involving the knee joint. In our opinion this joint is not as adequately treated as the hip joint, none of the sections being as thorough or up-to-date in their viewpoint as those which we have already pointed out so adequately cover the various lesions of the hip.

In the last volume we find the lower leg and foot well presented, their various lesions both congenital and post-traumatic as well as those due to disease being discussed. Following this there is a section on amputations in which various types of amputation are presented and their complications, together with a brief review of cinema plastic amputations and prostheses.

Finally considerable space is devoted to the more acceptable types of tendon transplant, both for the upper extremity and for the lower extremity as well. A brief résumé of surgical procedures used in the treatment of spastic paralysis, a chapter on equalization of leg length, both by actual lengthening and shortening operations and by epiphyseal operations is given. Finally, a chapter on the question of disability ratings in traumatic lesions is given.

We feel that the authors have made of this, the first extensive treatise published on orthopedic surgery, a most excellent work. They have brought orthopedics up-to-date, showing the type of orthopedic work done in the more advanced orthopedic clinics the world over. For the most part, emphasis is placed on the types of treatment used which will make the work appeal more to the practical minded. Some will be disappointed that their pet methods of treatment or points of view regarding etiology are not discussed, but on the whole, we believe, the authors have done an excellent job of selection of material and have presented it in a most acceptable form.

The form and style are excellent and the reproduction of photographs and roentgenograms is equally good.

We believe the treatise will find a wide field of usefulness.

Association for the Advancement of Science, Atlantic City, N. J., Dec. 29, 1936, to Jan. 1, 1937, edited by Henry Baldwin Ward. Occasional Publications of the American Association for the Advancement of Science, No. 4, June, 1937, supplement to Science, Vol. 85, 248 pages. Published by the Science Press, New York City, 1937. Price: cloth bound, \$2.50, paper bound, \$2.00.

This publication of a symposium on cancer held at the Atlantic City Meeting of the American Association for the Advancement of Science in its Section on Medical Sciences shows how diversified is the field of cancer research, and how diversified are the results and opinions of workers in this field. It can be read with interest and profit by all those who concern themselves with any of the various aspects of malignant disease.

SIEBZEHN JAHRE STRAHLENTHERAPIE DER KREBSE. Zürcher Erfahrungen, 1919-1935, by HANS R. SCHINZ and ADOLF ZUPPINGER. A volume of 340 pages, 95 figures, 213 tables. Published by Georg Thieme, Leipzig, 1937. Price: paper RM 32, bound RM 34. Less 25 per cent in U. S. A.

This monograph is a detailed statistical analysis of all of the 2,529 cases seen in the Universitäts Klinik, of Zurich, with special reference to survival of the various tumor groups after treatment. As was the case with practically all radiotherapeutic departments Schinz' earlier experience also was with the treatment of far advanced cases (in the total group treated only 24 per cent were operable). Statistically it is proven that with earlier diagnosis and earlier reference of the patients for radiotherapy, together with improvements and refinement of radiotherapeutic technique, the results are better. At present, protracted-fractional low intensity roentgen therapy (protrahiert-fraktionierte Röntgenlangbestrahlung) and teluradium therapy (Fernourietherapie) are the methods of choice in Schinz' clinic. The illustrations of the various steps of involution of tumors during treatment are well chosen, and, as is usual with all Thieme's publications, well reproduced. This book can be recommended to all radiotherapists who may be interested in finding out what one of the foremost European clinics is accomplishing in the treatment of malignant disease.

SOME FUNDAMENTAL ASPECTS OF THE CANCER PROBLEM. Symposium sponsored by the Section on Medical Sciences of the American

stereotyped, one could not help but be favorably impressed. In addition, the membership of the board of trustees of the American Foundation Studies in Government accredits the earnestness and thoroughness of this compilation.

The contributors hail from every State of the Union and represent every phase of medical education and practice, also, various groups as to years of practice.

The following items are some of the pertinent problems

What is "adequate" medical care?

Is the cost of it the only reason why it is not generally available?

How much modern scientific medical care of high grade exists at all?

If it were "available" now to all, would a large part of the population still choose quacks, cults, and patent medicine?

How far is government responsible for the health of the individual?

What part should government have in promoting public health and providing medical care?

Who should pay for the medical care of the indigent sick?

Is the old line of demarcation between preventive and curative medicine any longer practicable or desirable?

Can an individual doctor really furnish scientific medical care alone, or are organized laboratory and consultative assistance an absolute necessity?

In the medicine of the future will the practitioner function as an individual or as a member of a group?

What is the present status of the family doctor—is he "passing", or is a new version of him just coming into being?

Is the "doctor-patient-relationship" an absolute sentimentality or has it a practical value in modern scientific medicine?

Now that the age of philanthropy is passing, how are hospitals to be supported?

Is insurance—three cents a day—or direct use of tax funds the answer?

Should the United States have a Ministry of Health and set up a Federal Department of Health in the President's Cabinet?

The opinions as expressed by the various contributors are assembled into eleven sections. The first seven analyze, rather critically, what is right and what is wrong with American Medicine to-day.

The first four sections discuss various proposals for distributing medical care and lowering its cost, and for organizing medical care and public health services.

The opinions represent a cross section of substantial thought which, when amalgamated, should be of great assistance in crystallizing the fundamental principles involving the most important socio-economic activity of all human relations.

Medical services should be of the highest type, available to all, and—what is especially important is—a just reward to all members of the medical profession who have contributed hundreds of millions of dollars' worth of free services annually with the consequences that the desirable standard of living of the doctor and his family was needlessly sacrificed. No one can impugn the contributions of the medical profession, now is the time to make adjustments and who can co-operate more efficiently than the well informed, impartial, intelligent physician?

This work should be read by every physician, by every sociologist, by every economist, and by every industrialist. It is broad in scope, well classified, and pleasant to read—and how instructive!

TRAITE DE CHIRURGIE ORTHOPEDIQUE By L OMBREDANNE and P MATHIEU Volumes IV and V Published by Masson et Cie., Paris, 1937 Price, for five volumes, complete, 1250 francs

Volumes IV and V of this work conclude the series. These two volumes are for the most part devoted to a discussion of the conditions affecting the pelvis and lower extremities. These are adequately covered and, in our opinion, emphasis is well distributed over the various types of lesion, both traumatic and otherwise. The more modern methods of treatment of fractures are well discussed, that of the hip being well presented from all angles, both as to the treatment of the acute fracture and to the treatment of the pseudo-arthritis or "non union," as it is more commonly known in this country.

Other types of hip lesion are well discussed beside the fractures, excellent discussions being presented on the subjects of congenital dislocation, coxa vara coxa valga, coxa plana, traumatic dislocations acute arthritis and gonorrheal arthritis, coxalgia (tuberculosis),

ADDISON'S DISEASE

Calcification of the Adrenal Capsules H Tillier and Huguenin Bull et Mém Soc Radiol Méd de France, February, 1937, 25, 135-136

Roentgenograms of the renal regions in a case of Addison's disease demonstrated calcification of the adrenals confined largely to the cortex. The authors point out the value of the three-quarters view.

S RICHARD BEATTY, M D

ANIMAL EXPERIMENTATION

New Demonstration of a Reduced Regenerative Power of Tissue Following Roentgen Irradiation. B Dahl. Strahlentherapie 1937, 58, 482

The author studied the behavior of skin in rats following the application of erythema doses of roentgen rays. The capillaries were tested by the application of 50 per cent mustard oil and the healing tendency of the skin after producing a burn by means of a cautery. Young rats were used in the experiments, and the skin was studied both macroscopically and microscopically. Following a light degree of dermatitis, the hair reappeared completely and there were no adhesions in the subcutaneous fascia. The capillaries also appeared normal, however, their ability to dilate was definitely decreased. In the granulation tissue in the ulcers produced by the cautery there was definitely less vascularization although the ulcers healed. In cases in which the skin had shown higher degrees of dermatitis, permanent alopecia and slight atrophic changes were observed, with adhesions in the subcutaneous fascia. The capillaries dilated less and the skin was less resistant toward heat, but in this instance also the ulcers produced by the cautery healed after a slight delay.

ERNST A PORLE, M D, Ph D

APPARATUS

A Completely Protected High Tension Radiodiagnostic Apparatus M Delacour Bull et Mém Soc. Radiol Méd de France, January, 1937, 25, 76-80

To fill the need for a completely shock-proof unit of great capacity there has been developed the 'Multitral' unit designed to supply a number of radiographic or fluoroscopic tubes through shock-proof cables.

The high tension transformers, valve tube transformers, and four-valve tubes are contained in an oil filled metal case. Above this in the same unit are the special high tension switches operated electromagnetically by relays through a special switch block, for supplying the current to the various x-ray tubes. The regulating controls and meters are all included in a separate unit, the Synchro-pupitre which contains the Synchro-contacter.

The apparatus is equipped with autocompensators for the kenetron filaments and a stabilizer for the x-ray tube filaments.

The arrangement of the circuits with resistances in series with the current to each filament transformer, makes damage from surges almost impossible.

The unit is capable of delivering 500 ma at 95 kv p for instantaneous exposures. Oscillographic studies show that there is no tendency to surges, the tension is maintained evenly throughout the exposure.

S RICHARD BEATTY, M D

Presentation of Some Planigraphs M Buffé Bull et Mém Soc Radiol Méd de France, January, 1937, 25, 83-85

The production of x-ray films of single planes of the body by moving the tube and films in opposite directions about an axis at the level of the chosen plane has been completely discussed by others. In principle, the images of the other planes are effaced by blurring.

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S RICHARD BEATTY, M D

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The author describes a 200,000 volt installation with oil immersed, center-grounded transformers, oil-cooled target, shock-proof cables, and valve tube rectification which functions at 25 milliamperes. The control panel is equipped in addition to the usual instruments and controls, with circuit breakers which function when the flow of oil to the target ceases, a device preventing the sudden imposition of high voltages across the tube, and circuits permitting the oil pump to function on either of two lines in case one fails to provide current.

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S RICHARD BEATTY, M D

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S M ATKINS, M D, of Waterbury, Conn	E T LEDDY, M D, of Rochester, Minn.
S RICHARD BEATTY, M D, of Madison, Wis	ERNST A POHLE, M D Ph D, of Madison, Wis
J E HABBE, M D, of Madison, Wis	CHARLES G SUTHERLAND M B (Tor) of Rochester Minn
HANS W HEFKE, M D, of Milwaukee, Wis	
L G JACOBS M D, of Madison, Wis	

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ADDISON'S DISEASE

Calcification of the Adrenal Capsules H Tillier and Huguenin Bull et Mém Soc Radiol Méd de France February, 1937, 25, 135-136

Roentgenograms of the renal regions in a case of Addison's disease demonstrated calcification of the adrenals confined largely to the cortex. The authors point out the value of the three-quarters view.

S RICHARD BEATTY, M D

ANIMAL EXPERIMENTATION

New Demonstration of a Reduced Regenerative Power of Tissue Following Roentgen Irradiation B Dahl. Strahlentherapie 1937, 58, 482

The author studied the behavior of skin in rats following the application of erythema doses of roentgen rays. The capillaries were tested by the application of 50 per cent mustard oil and the healing tendency of the skin after producing a burn by means of a cautery. Young rats were used in the experiments and the skin was studied both macroscopically and microscopically. Following a light degree of dermatitis the hair reappeared completely and there were no adhesions in the subcutaneous fascia. The capillaries also appeared normal, however, their ability to dilate was definitely decreased. In the granulation tissue in the ulcers produced by the cautery there was definitely less vascularization although the ulcers healed. In cases in which the skin had shown higher degrees of dermatitis, permanent alopecia and slight atrophic changes were observed, with adhesions in the subcutaneous fascia. The capillaries dilated less and the skin was less resistant toward heat but in this instance also the ulcers produced by the cautery healed after a slight delay.

ERNST A POHLER M D, Ph D

APPARATUS

A Completely Protected High Tension Radiodiagnostic Apparatus M Delacour Bull et Mém Soc. Radiol Méd de France, January 1937, 25, 76-80

To fill the need for a completely shock-proof unit of great capacity there has been developed the "Multitravail" unit designed to supply a number of radiographic or fluoroscopic tubes through shock proof cables.

The high tension transformers, valve tube transformers and four-valve tubes are contained in an oil-filled metal case. Above this in the same unit are the special high tension switches operated electromagnetically by relays through a special switch block, for supplying the current to the various x ray tubes. The regulating controls and meters are all included in a separate unit the "Synchro-pupitre," which contains the Synchro-contacter.

The apparatus is equipped with autocompensators for the kenotron filaments and a stabilizer for the x-ray tube filaments.

The arrangement of the circuits with resistances in series with the current to each filament transformer, makes damage from surges almost impossible.

The unit is capable of delivering 500 ma at 95 kv p for instantaneous exposures. Oscillographic studies show that there is no tendency to surges, the tension is maintained evenly throughout the exposure.

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therapie, 1926, 56, 497) The author reports in this paper in detail the results of his physical, biological and clinical investigations. A device for concentrating the ultra violet radiation and applying it under compression is also described. The skin reactions were studied both macroscopically and microscopically. These preliminary observations seem to indicate that the new lamp is superior to the Finsen lamp in the treatment of neurodermatitis.

ERNST A. POHLE, M.D., Ph.D.

Apparatus for the Accumulation of Energy for the Utilization of High Tension for Instantaneous Exposures. P. Lorimy. Bull. et Mém. Soc. Radiol. Méd. de France, January, 1937, 25, 64-66.

An accessory apparatus has been developed, which when placed in the circuit between the current source and the high tension generator, makes it possible to develop very high tension for short exposures. A monophasic alternator of low internal resistance furnished with a heavy fly wheel and driven by an electric motor makes it possible to utilize the kinetic energy for generation of high tensions.

Exposures of the order of $\frac{1}{100}$ seconds at 30-60 kv. are possible with variations of only 1 per cent in time and 10 per cent in the resistance of the alternator.

It is possible to utilize the apparatus over a wide range of fluoroscopic and radiographic requirements through a simple system of controls.

S. RICHARD BEATTY, M.D.

BIOLOGIC EFFECTS OF RADIATION

The Therapeutic Value of the Biologic Destructive Action of Roentgen Rays. Edmondo Ingber. *Archivio di Radiologia* 1936, 12, Nos 3-4, 244-254.

This address in memory of Guido Holzknecht and Fritz Pordes is well worth reading in the original.

E. T. LEDDI, M.D.

BONE DISEASES (DIAGNOSIS)

Squamous Epithelial Bone Cysts of the Terminal Phalanx. A. D. Bissell and Albert Brunschwig. *Jour. Am. Med. Assn.*, May 15, 1937, 108, 1702-1704.

It is generally stated that such cysts are of traumatic origin and are due to proliferation of a small fragment of cutaneous epithelium that is carried into the deeper tissues. That such epithelial cysts not only occur in the soft tissues but may also extensively involve the phalanges is shown by reports in the literature. An adequate history of trauma was found in only a proportion of reviewed cases, but the evidence in their own cases favored traumatic deep implantation of a fragment of cutaneous epithelium as a more probable etiologic factor than displaced embryonic rests.

Non-malignant stratified squamous epithelium may invade bone under other circumstances. (1) The squamous epithelial lining of dentigerous cysts is the

result of downgrowth of gingival mucosa along the sinuses sometimes present between the gingival surface and the cyst cavity. (2) Chronic osteomyelitis cavities in the long bones may become partially or completely lined by downgrowth of the cutaneous epithelium along the draining sinuses. In tuberculosis of the calvarium small cavities within the diploe may present an epithelial lining also the result of downgrowth of the cutaneous epithelium of the scalp along open sinuses. From a review of the reported cases the authors felt the following clinicopathologic entity might be described.

Traumatism to the distal portions of the fingers may be followed shortly or after a prolonged period by progressive slightly or markedly tender diffuse swelling of the distal phalanx without other evidence of infection. Also, such symptoms may develop in the absence of a history of trauma. In the roentgenogram a central expanding cystic lesion of the terminal phalanx is seen that has destroyed a portion or almost all of the bone. These are frequently interpreted as chondromas. At operation a cyst is found that is easily peeled away from the surrounding bone. This cyst contains sebaceous material and is lined by squamous epithelium. The lesions are benign, but recurrences may develop if removal is incomplete.

Pre-operative differentiation from solitary bone cyst, giant-cell tumor, or chondroma is not possible. The treatment of choice is surgical excision.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Metastasis in a Bang's Infection. F. Hart Horstmann. *München med. Wchschr.* June 18, 1937, 84, 984-985.

This is a case report describing a man aged 41, in whom a Bang's infection (brucellosis with *B. abortus*) produced a localized osteomyelitis and bone abscess in an osteoma of the left thigh. Spontaneous resolution of the process took place.

L. G. JACOBS, M.D.

Localized Transverse Lines at the Metaphyses of Long Bones. N. R. Braun. *Röntgenpraxis*, November 1936, 8, 746.

Transverse lines of increased density at the metaphyses of long bones are known to occur after different systemic diseases as pneumonia, typhoid fever, rickets, hyperthyroidism, etc. They are then found more or less generalized in most all of the long bones. The localized occurrence of these dense lines of increased calcium content is rare. It is apparently due to exogenous causes, mostly rickets in combination with local irritation such as deformities or fractures.

HANS W. HEFKE, M.D.

Brittle Bones and Blue Scleras. Editorial. *Jour. Am. Med. Assn.* May 8, 1937, 108, 1657-1658.

Four distinct features characterize this clinical

entire blue scleras, fragile bones, a tendency to deafness and marked relaxation of the ligaments. The disease follows the mendelian laws of inheritance, appearing as a dominant character. Hills and McLanahan (*Arch Int Med* January, 1937, 59, 41) present a detailed consideration of the etiology, pathologic changes and treatment in a case which they report. Data were gathered on 51 other members of the same family. The family tree shows the appearance of characteristic signs of the syndrome in 27 of the 51 family members. The pathology and hereditary features of this disease have been comprehensively treated by Kev (*Arch Surg*, October 1926 13, 523) and by Bell (in Pearson Karl *Treasury of Human Inheritance* Cambridge University Press, London 1928, vol 2, pt 3, sect 24).

CHARLES G. SUTHERLAND, M B (Tor)

BREAST CANCER

Simple Post-operative Radiation Therapy of Cancer of the Breast with High, Fractionally Applied Total Dose. F. Melchart. *Strahlentherapie*, 1937, 59, 312.

In 1932 the author treated 50 patients after surgical removal of a breast cancer with one series of treatments and reports now his preliminary results at the end of a four-year period. The entire breast region, including the supraclavicular area and axilla, was irradiated. The single doses varied from 130-240 r per day at 0-24 r/min with total doses of 2,400-4,700 r. Forty seven patients completed the prescribed series of treatments. The clinical data are presented in tabulated form. The classification of Steinthal has been adopted. At the end of four years six out of eight patients (Stage I), 11 out of 17 patients (Stage II), and 3 out of 25 patients (Stage III) were alive. None of the cases showed fibrosis of the lungs.

ERNST A. POHLE, M D, Ph D

My Method of So-called Prophylactic and Curative Post-operative Irradiation in Carcinoma of the Breast. G. G. Palmieri. *Strahlentherapie*, 1937 59, 298.

The author describes his method of post-operative x ray therapy in carcinoma of the breast by means of a 'paraffin filter' which serves as a source of scattered radiation. He claims that the total treatment time is considerably reduced with this equipment and that the depth dose 3-5 cm below the skin compares well with those which have been obtained at focal skin distances of 70-80 cm but requires four times the time. The clinical material is too small to draw final conclusions as to the end results.

ERNST A. POHLE, M D, Ph D

CANCER (DIAGNOSIS)

Development and Differential Diagnosis of Bronchial Carcinoma. Walter Naumann. *Röntgenpraxis* March 1937 9, 152-160.

The author reviews the roentgenological aspect of 74

cases of bronchial carcinoma, seen during a span of ten years. He divides all cases into two groups.

In the first group there is no evidence of the tumor as such at first, atelectasis and occasionally disturbances in the movement of the diaphragm are the only signs. The so-called mediastinal wandering was seen in only two cases. At times glandular metastases are the first sign of a malignant tumor of the lung.

In the second group the tumor can be seen as such because it has infiltrated the lung itself.

In only nine of the 74 cases the so-called hilus carcinoma was seen, while in 35 cases either an entire lobe or large portions of one were involved. Pleuritic effusions were seen only in advanced stages.

The differential diagnosis from other diseases of the lungs is considered. The progress of bronchial cancers is usually not influenced by therapeutic radiation. The author saw occasionally temporary clearing of an atelectasis. About 20 per cent showed a noticeable, even though only temporary, improvement.

HANS W. HEFKE, M D

Biologic Properties of the Blood in Cancer. M. Ascoli. *Le Cancer* 1935, 12, 266-270.

A greater quantity of lipoids rich in unsaturated valences can be extracted from the serum of cancerous patients than from normal serum when these sera are dried on filter paper and extracted with cold ether. The author calls these 'disposable' valences. He defines a 'disposability quotient' between the total unsaturated valences in an alcohol-ether (hot) extract of dried serum and these disposable valences which is in the neighborhood of six in normal states and even in disturbances of the lipid metabolism as in nephrosis. In cases of malignancy only the 'disposable valences' increase and the quotient becomes two. This disturbance is found not only in the serum but also in the corpuscular part of the blood and the tissues in general.

It is possible to produce this modification in animals by endoperitoneal injection of tar or benzopyrene.

Several other phenomena produced by the presence of these 'disposable valences' are described. The glycolytic powers of cancerous blood cells are above normal. This effect can be produced *in vitro* by adding sera or organ extracts of cancerous individuals or tumor extract to normal blood cells.

The best method of demonstrating the change in ratio of 'disposable valences' is by means of determination of the iodine number. The results have been confirmed in the gynecologic and urologic fields by others.

S. RICHARD BEATTY, M D

Acute Syndromes of Metastasis. Renc. Huguenin. *Le Cancer* 1935, 12, 213-226.

Not usually, but quite frequently the dissemination of metastases from a malignancy is accompanied by acute symptoms, which may simulate the syndromes of other clinical entities. The author cites three classes of such syndromes: the *abdomino-hepatic* in which

metastases may give the clinical picture of peritonitis, cholecystitis, liver abscess, etc., with sudden and severe fever pain, and vomiting which may lessen or disappear within a few days to be followed by the usual symptoms of metastatic malignancy, *the neurologic syndromes*, simulating encephalomalacia or cerebral accident, *the pulmonary syndromes* in the forms of pneumonia, pleurisy or tuberculosis, especially as the nodules are not always visible radiographically early

That these syndromes occur so suddenly and are so frequently associated with alterations of the vascular beds is an important hint as to the etiology of metastasis

The clinician, especially in caring for those patients known to have cancer or to have had a cancer believed cured must keep these syndromes in mind to avoid making false diagnoses and prognoses

S RICHARD BEATTY, M D

Diagnosis and Progressive Changes of Bone Metastases in a Clinically Not Diagnosed Case of Cancer of the Thyroid R Finsterbusch and G Schumann Röntgenpraxis, November, 1936 8, 735

The records of the University Clinic of Leipzig of 50 cases of cancer of the thyroid showed bone metastases in 8 per cent of these cases. A very interesting case is described in which the primary tumor was never diagnosed clinically. Extensive radiological changes were observed in the pelvic bones over a period of nine years. They were diagnosed as metastases only shortly before the death of the patient. The appearance of these large lesions was that of an osteitis cystica. It changed very little in size during the course of eight years. Other bone metastases were later found in skull scapula and spine

HANS W HEFKE M D

Color of Hair and Eyes in Cancer Patients E Beuster Strahlentherapie 1937 59, 282

The author recorded the color of hair and eyes in 500 patients with cancer as compared with 500 controls. Light hair and light eyes were found in the majority of cases with carcinoma of the skin, esophagus and the jaw. This preponderance was not noted in women with carcinoma of the genital organs, the breast, nor in carcinoma of the larynx.

ERNST A POHLE M D Ph D

Cancer of the Sub hepatic Regions J Pelnar Le Cancer, 1935 12, 227-237

Carcinomas of the gall bladder, of the extra hepatic bile ducts, of the ampulla of Vater, of the head of the pancreas and a certain number of those of the body of the pancreas, considered as a group occur almost as frequently as cancer of the stomach being found in a ratio of 13.5 per thousand autopsies as compared with 16 per thousand for carcinoma of the stomach. They are rapidly fatal and early diagnosis is necessary. As a group they have in common a series of important

symptoms and signs which should make it possible to suspect their existence in the initial stage.

From his personal experience (90 cases), the author outlines the symptomatology of this group of carcinomas and suggests the diagnostic procedures useful in confirming a diagnosis. The symptomatology is given in tabular form.

S RICHARD BEATTY, M D

CANCER (THERAPY)

Radiation Treatment of Carcinoma of the Buccal Cavity Richard Dresser and Charles E Dumas Am Jour Roentgenol and Rad Ther December 1936 36, 939-944

While in some clinics carcinoma arising from the tissues of the mouth has come to be considered a radiation therapy problem entirely, the writers' opinion is that a small well localized lesion in the anterior floor of the mouth is better handled by adequate resection. For intra-oral roentgen radiation of mouth lesions, special lead cones have been devised the lower part of the special cone being of several sizes to permit appropriate inclusion of the field of the tumor, depending upon its size. By this device the distance from target to tumor is fixed at 25 cm. Single doses of from 1500 to 2000 r at 200 kv with 0.5 mm copper were thus administered directly to the tumor if a small lesion or larger doses are given by dividing the dose. Cross fire of the tumor by neck radiation supplements the intra-oral treatment.

Four hundred r given daily for a week for a total dose of 2400 r accomplishes much the same clinical results and the same skin and membrane reactions as 200 r daily for three weeks for a total dose of 4000 r. If about four weeks after 2400 r is given in a week the tumor masses show satisfactory regression 400 to 1200 r is given in from two to three days and this may be repeated once again after another three to four weeks. When the cervical glands become fixed indicating invasion beyond the capsule permanent regression can not be accomplished.

Repetition of the above dosage should not be repeated even after several years. Neither should attempts be made to surgically excise glands from tissues so irradiated since such tissues have very poor resistance against infection.

J E HABBE M D

Direct Roentgen Irradiation of Deep seated Tumors Sherwood Moore Am Jour Roentgenol and Rad Ther December 1936, 36, 969-979

The author argues strongly for distinct modifications of the accepted methods of radiation therapy of malignancies when these are accessible to surgical exposure. He points out that most failures are brought about by under-dosage due to fear of ill-effects in the overlying skin or membranes. He also expresses the opinion that roentgen sickness is largely attributable to action of x rays upon the skin. The method employed is to have

the tumor exposed surgically with the skin flaps carefully sutured back and protected against all radiation by lead foil. The tumor is then immediately radiated, often with the patient under anesthesia. Both low voltage (85 kv) without filter, and moderate voltage (160 kv constant potential) with 0.25 mm copper filter have been the techniques employed. Metastatic carcinoma in the glands of the neck, in the axilla, and primary carcinoma in the base of the bladder, carcinoma of the lung, the rectum, and tumors of the brain have been so treated with single doses varying from 1,000 to 5,000 r. Immediately following the x-ray treatment the surgical wound is closed and prompt healing without complications has been the rule.

Sufficient good results from surgically inoperable cases have been obtained to justify continuance of the method.

J E HABBE M D

Advanced Cancer of the Head and Neck. Charles L. Martin. *Am Jour Roentgenol and Rad Ther*, December 1936, 36, 954-962.

In the treatment of advanced carcinomas of the head and neck the experiences of the writer prove the value of heavy filtration as advocated by Merritt and Rathbone with intensity being a less important consideration although the best results occurred when rates of 12-16 r per minute were used. When using 0.75 mm copper plus 1.0 mm aluminum, the following total doses are considered the top of safe limits according to the size of the field: 4,200 r for 7 cm in diameter, 3,600 r for 15 cm in diameter, and 2,800 r for 20 cm in diameter.

At times the external x radiation is augmented by radium needles implanted into the gland secondaries such treatment usually being given for from five to seven days just preceding the external series.

The writer warns against any such modified Coutard technique for cases showing skin tanning from previously administered massive doses of x rays.

J E HABBE M D

Radiotherapeutic Experiences with Malignant Tumors of the Upper Respiratory and Digestive Tracts Complicated by Regional Lymph Gland Metastases. A. Pagani. *Strahlentherapie* 1937 59, 441.

The author analyzed the cases with tumors of the lip and oral cavity accompanied by metastases in the lymph glands which had been observed during the period 1919-1935. After a careful study of 88 patients seen during that period he offers certain conclusions. The treatment of the glandular area in these cases is indicated only if the local tumor has been or can be eradicated. If no lymph glands are involved he recommends especially for primary tumors in the anterior part of the tongue a prophylactic series of x ray therapy applied according to the fractional dose method. In cases with small local tumors which can be cured by radium application any suspicious but still operable lymph glands should be removed. If histological ex-

amination shows invasion, they should be irradiated following operation. The same doses should be used in such cases as if the operation had not been performed.

More advanced cases may be treated by simple fractional doses or by the protracted fractional dose method. If in these patients the local tumor disappears and some of the involved glands remain after treatment, they should be removed. The end results of this series of cases or all with involvement of lymph glands in the beginning of the treatment, were 15 per cent for a three year period and 10 per cent for a five year period. The results of the protracted fractional roentgen therapy were approximately the same as of the combined radiosurgical therapy. The final outcome depends not only on the size of the primary tumor but also on the amount of metastases. So far no single case of intra-oral carcinoma with involved lymph glands attached to the underlying structures could be permanently cured.

ERNST A. POHLE M D, Ph D

Prophylactic Post-operative Irradiation. H. R. Schinz. *Strahlentherapie*, 1937 59, 291.

The author undertook an evaluation of the post-operative irradiation in carcinoma of the breast and cervix. If this is done systematically he believes that post-operative radiation therapy definitely improves the end-results.

ERNST A. POHLE, M D, Ph D

Post operative Radiation Therapy in Cancer. H. Wintz. *Strahlentherapie* 1937 59, 305.

The author analyzes the problem of post operative radiation therapy in patients with carcinoma. He wishes to make a definite distinction between post-operative irradiation in cases with incomplete operation, irradiation of post-operative recurrences, and true prophylactic radiation therapy. The latter comprises those cases in which radiation therapy is given in order to prevent a recurrence following complete surgical removal of tumors. Up to this date there seems to be no evidence proving that prophylactic radiation therapy can prevent the development of cancer. The author also gives his reasons for preferring pre-operative irradiation to radiation therapy following operation. His statistics for carcinoma of the breast seem to show that the results are better if irradiation is applied before surgical removal of the tumor.

ERNST A. POHLE M D Ph D

Critical Remarks Regarding Prophylactic Post-operative Radiation Therapy. W. Altschul. *Strahlentherapie*, 1937 59, 340.

The author discusses the value of post-operative radiation therapy. He wishes to distinguish the true prophylactic irradiation from the post-operative irradiation for recurrences. Practically, this is not always possible because one cannot definitely say whether active or dormant cancer cells are left in the area operated upon.

He proposes, therefore to give post operative irradiation therapy in two stages first the entire tumor area, at the same time shielding the regional lymph glands and three or four weeks later irradiating all regional lymphatics

ERNST A. POHLE, M.D., Ph.D.

Treatment of Malignant Tumors of the Larynx and Pharynx E. Wessely *Strahlentherapie*, 1937, 58, 641

The author briefly reports his experience with the Coutard method in the treatment of 174 cases of carcinoma of tongue, epiglottis, hypopharynx, and larynx. While he is not prepared yet to present statistics based on five year survivals he feels that this treatment method offers a chance to patients whose lesions have become inoperable.

ERNST A. POHLE, M.D., Ph.D.

Experiences with the Low Voltage Therapy in Skin Carcinoma H. Quastler *Strahlentherapie*, 1937, 59, 182

The author gives a brief preliminary report regarding six patients with carcinoma of the skin treated by Chaoul's method. He used 70 kv. 0.25 mm. Al, single doses of from 300 to 500 r and total doses of from 5,200 to 10,000 r. In some cases he alternates the low voltage technique with radiation of higher penetration. The immediate response to the treatment method was very satisfactory although no final conclusions can be offered at this time.

ERNST A. POHLE, M.D., Ph.D.

THE COLON

Meckel's Diverticulum Howard K. Gray and James W. Kernohan *Jour. Am. Med. Assn.*, May 1, 1937, 108, 1480-1483

This is a report of a case of Meckel's diverticulum associated with intussusception and adenocarcinoma of ectopic gastric mucosa in a married woman aged 37.

That there is a persistence of the proximal end of the yolk stalk to form a pouch at its point of union with the intestine in approximately 3 per cent of all individuals has been widely recognized. This pouch is usually referred to as "Meckel's diverticulum" and is a structure of clinical importance because of the rôle it may play in producing intestinal obstruction. Benign ulcerating processes in ectopic gastric mucosa have been described with relative frequency and have been incriminated occasionally as the source of intestinal hemorrhage. The development of malignant lesions in the ectopic gastric mucosa of a Meckel's diverticulum is extremely rare.

Roentgenographic examination of the colon in this patient revealed a filling defect involving the ileocecal region at a point that coincided with the position of a palpable mass. The changes suggested an extraluminal mass. Surgical investigation elicited an intussusception of the terminal portion of the ileum about 35 to

40 cm above the ileocecal junction. A portion of bowel that had become invaginated for approximately 8 cm was easily reduced. The ileocecal region was essentially normal. A second intussusception had occurred in a portion of tissue which appeared to be a large Meckel's diverticulum. At the tip a portion of the mesentery of the diverticulum had become intussuscepted into the bowel. It was impossible to reduce this and a segmental resection of the ileum was performed by making an end-to-end anastomosis.

Examination of the tissue removed demonstrated heterotopic gastro-intestinal tissue chronically inflamed, occupying the entire middle third of the diverticulum and this portion gradually merged into the distal third which was the site of an adenocarcinoma. There was a gradual transition between the heterotopic gastric mucosa and the carcinoma at the tip.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Comparison of Methods of Roentgen Examination of the Colon James T. Case *Jour. Am. Med. Assn.*, June 12, 1937, 108, 2028-2034

Routine practice in intestinal x-ray examinations includes the opaque meal with appropriate screen or film observations of the opaque residues as they move along the large bowel, followed by the contrast enema administered under screen control by the physician radiologist himself with appropriate film records during the course of the fluoroscopy and subsequent observations after the patient has attempted to expel the contrast fluid. The combination of these two series of observations constitutes a complete gastro-intestinal roentgenologic study.

On the whole, it may be said that the colonic study with the opaque meal gives information more especially regarding function whereas the contrast enema affords data relating to organic lesions, the two methods overlapping somewhat in their usefulness and yet often supplementing each other in a very precise manner. The opaque meal is time-consuming whereas the contrast enema or some elaboration of it can be accomplished within a short time. The presence of such a condition as anal insufficiency may necessitate the use of the barium meal study even though the contrast enema would be the method of preference. There is also use for the oral contrast method preferably by the use of umbrathor in cases in which the contrast enema has revealed a serious obstruction and the radiologist does not wish to force passage of the stricture and yet wishes to obtain information regarding the digestive tube proximal to the stricture.

The single contrast enema employed under roentgenoscopic control is the most expeditious simple convenient and generally useful method of study of colonic morphology. It should be administered by the roentgenologist at a rate sufficiently slow to allow adequate screen study and such fluororadiographic film records as seem required.

Fischer in 1923 popularized the idea of the double contrast method combining the contrast enema with

air insufflation of the colon The next stage of technical progress in colonic investigations was the development of methods for showing the internal mucosal relief of the digestive organs originated by Forssell Weber, Gershon-Cohen and others have led in re-establishing interest in air injections of the colon following the barium sulfate enema and have brought the "combined method" or "double contrast method" to a high stage of refinement in technic and interpretation in the search for some means of making an earlier diagnosis of carcinoma of the colon, in differentiating various types of colitis, and particularly for the discovery of small polypoid growths and mucosal alterations

CHARLES G SUTHERLAND M B (Tor)

CONTRAST MEDIA

The Use of Thorium Dioxide in the Roentgenographic Study of Liver Abscess Robert J Reeves Am Jour Roentgenol and Rad Ther December 1936, 36, 923-927

While it must be remembered that thorium dioxide, when injected into the blood stream and fixed in the liver and spleen by the reticulo-endothelial cells, emits small quantities of high energy radiation comparable to that of gamma rays of radium it has not been found to produce clinical manifestations of late ill effects in patients who have submitted to the injection as long ago as seven years If there is clinical suspicion of metastatic malignancy in the liver, or of liver abscess the use of the drug is considered justified Ordinarily the entire dose of 75 c c of thorium dioxide suspension diluted with 100 c c salt solution is given at a single dose intravenously and films are taken five days later Six cases of liver abscess, localized by means of this procedure are presented

J E HABBE, M D

Potential Hazards of the Diagnostic Use of Thorium Dioxide Editorial Jour Am Med Assn, May 8 1937 108, 1656 1657

When injected into a vein thorium dioxide sol remains indefinitely in the reticulo-endothelial system especially in the liver and spleen The immediate utility of colloidal thorium dioxide preparations has tended to obscure an important characteristic of this substance its radio activity Because patients who have received injections of this compound have shown no apparent ill effects over a period of years some clinicians conclude that the preparation is safe and have begun to employ it with less caution

The degradation products of thorium emit alpha rays more penetrating than those of the radium series This ray is about 10,000 times as toxic to tissues as the gamma ray which is used therapeutically The alpha rays are filtered out in therapeutic use of radium and their effects are seen only when the material comes into direct contact with tissues as on ingestion or injection An amount commonly used for intravenous injection

of one of the commercial preparations of thorium dioxide has an alpha-ray activity equivalent to that of from 1 5 to 3 micrograms of radium

Experience with radio active intoxication indicates that as much as ten or fifteen years (and perhaps longer) may elapse between ingestion of the active material and the onset of gross tissue changes

CHARLES G SUTHERLAND M B (Tor)

DEEP THERAPY

A Year's Experience with 800 kv Roentgen Rays Howard E Ruggles Am Jour Roentgenol and Rad Ther, September, 1936, 36, 366, 367

From 300 patients treated the conclusion drawn is that there is no improvement in the primary results over that of 200 kv

S M ATKINS M D

Comparative Clinical Value of Supervoltage Roentgen Therapy T Leucutia Am Jour Roentgenol and Rad Ther, September 1936, 36, 350-365

The advantage of this voltage lies in the better distribution and the creation of more advantageous absorption conditions within the tissues irradiated

S M ATKINS M D

GALL BLADDER (NORMAL AND PATHOLOGIC)

The Stoneless Gall Bladder Carl A Kunath Jour Am Med Assn July 17, 1937, 109, 183-187

This is an analysis of 100 cases treated by cholecystectomy Compared with a similar series of cases in which stones were present the stoneless cases showed a greater morbidity, a higher post-operative mortality, and only about half as many cures

The stoneless cases were analyzed carefully from the standpoint of cholecystographic evidence and also pathologic changes present in the gall bladder wall, but little help was offered from either of these sources in regard to prognosis following cholecystectomy In general, the end results tended to be better as the pathologic changes became more marked, but there are many queer aspects which are difficult to reconcile

An analysis of the pre-operative symptoms revealed cure of colic in 86 per cent of cases in which it was present. Cures of dyspepsia were only 33 per cent Of the patients who did not complain of dyspepsia prior to operation 38 per cent had such symptoms after operation This would seem to be a strong argument in favor of the view that the dyspepsia syndrome is related not so much to disease of the gall bladder as to non function of the gall bladder

Although a few poor results could possibly be ascribed to residual pathologic changes in the pancreas liver, or bile ducts it was not possible to incriminate definitely any of these organs

Errors in diagnosis duodenal ulcer, duodenal diverticulum a tuberculous spondylitis and a chronic gono

coccic peritonitis, irritable intestine, and spastic conditions of the gastro-intestinal tract (in by far the majority) explained the poor results

The great majority of unimproved cases had to be explained on a basis of physiologic changes or altered function. There was probably a large group of cases in every series of stoneless gall bladders lying on the borderline between organic and functional disease, these were the cases in which diagnosis was difficult and in which cholecystectomy was apt to be disappointing

The hope for improvement in the treatment of the stoneless gall bladder appeared to depend on a better understanding of the physiology of the biliary tract

CHARLES G. SUTHERLAND, M B (Tor)

Cholesterosis of the Gall Bladder Editorial Jour Am Med Assn June 12, 1937 108, 2042, 2043

The preponderance of experimental proof seems to indicate that the gall bladder absorbs cholesterol from the bile and that the cholesterosis is probably an infiltrative process. Infection though frequently associated with cholesterosis is not an essential factor and may be entirely absent. The relation of diet of cholesterol metabolism, of cholesteremia, and of inflammation to cholesterosis and stone formation awaits further study

CHARLES G. SUTHERLAND M B (Tor)

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Drugs as an Aid in Roentgen Examination of the Gastrointestinal Tract Max Ritvo Am Jour Roentgenol and Rad Ther December, 1936 36, 868-874

Spasm, atonicity, and inhibited peristalsis are all factors tending to interfere with prompt satisfactory examination of the gastro intestinal tract by the roentgen method. Atropine and belladonna have long been recommended as aids to overcoming spasm, but these have been discarded as unsatisfactory by Ritvo. For increasing tonus and peristalsis mecholyl (acetyl-beta methyl-cholin) or physostigmine may be used. Mecholyl is not suited to clinical examinations because of unpleasant reactions but physostigmine salicylate or sulphate in $\frac{1}{25}$ grain doses per mouth or about $\frac{1}{10}$ grain subcutaneously will increase peristalsis for from 15 to 30 minutes and increase tonus for an hour or more. Physostigmine should not be given in late pregnancy, advanced heart disease or iritis.

To overcome spasm, particularly of the stomach, benzedrine sulphate in from 20 to 30 mg doses administered orally has been found very effective. For enema examination the colon injection may be greatly

facilitated by giving the drug from 15 to 30 minutes before commencing the examination. The administration of this drug is followed by a feeling of well being but tends also to interfere with sleep for a few hours hence it should not be given late in the afternoon. Because this drug produces a moderate rise in blood pressure it should be withheld in cases of moderate or marked hypertension.

J. E. HABBE M D

Allergic Gastritis and Allergic Pyloric Spasm K Hansen and M Simonsen Röntgenpraxis March 1937 9, 145-151

Gastric symptoms on a nutritive allergic basis are caused by a hyperergic gastritis and pyloric spasm. Both are found every time a specific antigen against which an allergy exists is taken with the food. These antigens are often egg protein and milk. The allergic reaction of the stomach is very marked. It usually lasts only a short time and disappears soon after the elimination of the antigen. If the antigen is introduced into the stomach repeatedly for a long time, a chronic gastritis might result, to disappear only slowly after the beginning of an antigen free diet.

Roentgenologic changes due to an allergic gastritis can be demonstrated readily if the antigen is mixed with the barium meal. Some case reports illustrate the authors' contentions.

HANS W. HEFKE M D

Radiologic Diagnosis in Two Cases of Intestinal Obstruction LaMarque and Bétoulhères Bull et Mém Soc Radiol Méd de France, January, 1937, 25, 29-31

In the case of a man 68 years of age with symptoms leading to a suspicion of gastric carcinoma a barium meal made positive a diagnosis of crural hernia. The intestine was filled with fluid and the usual gas shadows were absent.

In a second case presenting symptoms of obstruction, a gas filled loop of intestine was found above the left diaphragm. The barium meal disclosed this to be the herniated splenic flexure and demonstrated a mega colon.

S. RICHARD BEATTY M D

Diverticulum of the Duodenum after Operation H Albers Deutsche med Wchnschr 1937 63, 1111

The author discusses briefly the clinical symptoms of diverticulum of the duodenum and then reports a case with a history of symptoms of 15 years duration. The correct diagnosis was not made until then following roentgen examination. Differential diagnosis classification of diverticula and the treatment are briefly discussed. Three roentgenograms are appended.

ERNST A. POHLE M D Ph D

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THE DEVELOPMENT OF POST-GRADUATE TEACHING IN RADIOLOGY

By GEORGE W. HOLMES, M.D., *Boston*

Clinical Professor of Roentgenology, Harvard Medical School, and Chief of the Roentgenological Service of the Massachusetts General Hospital

THE Carman Lecture was established by the Radiological Society of North America at its twentieth annual meeting in Memphis, Tenn., on Dec. 3, 1934, to do honor to the memory of a great radiologist. On an occasion such as this, when radiologists from various countries are gathered, it is fitting to review the life of the man in whose honor we are assembled.

Russell Daniel Carman was born at Iroquois, Ontario, Canada, on March 18, 1875. He came to the United States in boyhood and later became a citizen of this country. His early education was obtained at Minneapolis Academy, and the first two years of his medical training at the University of Minnesota. He then went to St. Louis, Mo., where he completed his course in medicine at the Marion-Sims College, receiving the degree of Doctor of Medicine in 1901. At the end of one year's post-graduate work at Johns Hopkins Medical School in Baltimore, he returned to St. Louis to practise medicine.

In 1902 radiology was in its infancy, and Carman became one of its early disciples. Recognized as a leader in his field, he was invited to the Chair of Professor of Roentgenology at the Medical School of St. Louis University, from which he resigned to take a similar position at Washington University. Jan. 1, 1913, upon the joint invitation of the Staff, he became head of the Section of Roentgenology at the Mayo Clinic, and retained this position until his death in 1926. Through his long association with this great institution he did much to place radiology as a specialty of medicine upon the firm foundation which it now occupies.

Carman will always be remembered for his contributions to the roentgenological diagnosis of diseases of the gastro-intestinal tract. The present high standard of diagnosis in this field is probably due more to

his efforts than to those of any other one American. The magnitude of his work in gastro-intestinal diagnosis has somewhat obscured his contributions in other fields. Carman was not only a great diagnostician but a great teacher, and it is this phase of his work which should interest us particularly this evening. As a teacher he recognized two principles which seem to me to be of the greatest importance in the development of radiology. First, the careful selection of the individuals who are to enter this field of endeavor, and second, a planned, adequate, supervised course of instruction. That he was highly successful in his selection of candidates is amply shown by the men whom he left to succeed him. Among these are Dr. B. R. Kirklin, who is the present head of the Section of Roentgenology at the Mayo Clinic, and President of the American Roentgen Ray Society, and Dr. John D. Camp, whom you have honored with the Presidency of your Society. The real measure of a great teacher is found not in the number of students who pass through his clinic, but in the number, though they may be few, who become recognized leaders in the science which he represents. Judged by this standard Carman was eminently successful.

The establishment of the Mayo Foundation in 1916 gave Carman an opportunity to take part in the development of a three-year course of post-graduate instruction in the specialties. This plan has since been adopted, with some modifications, in many of the more important teaching institutions in this country. The development of post-graduate teaching in radiology, which is the subject of our discussion this evening, owes much to Russell Carman.

The training of men in the medical specialties is a subject of great interest to physicians and to teachers throughout America to-day. This interest has been

augmented by the establishment of examining boards in each of the various specialties and by an attempt on the part of organized medicine to raise the standards of teaching. Before attempting to outline a program of instruction in any special medical field, and particularly in radiology, it seems to me desirable to review briefly the methods of teaching used in the past through which our present leaders received their instruction. In addition we should determine, as far as possible, the number of radiologists necessary to carry on the work and should know in which institutions adequate training may be obtained. In other words, how have our leaders in the past been trained? How many roentgenologists are necessary? What are the present facilities for training them?

In the early days of medicine in this country, specialization was entirely a matter of individual growth. If a physician showed some aptitude for certain phases of medicine, or became particularly interested in some one disease, patients were referred to him by his colleagues, or came directly to him because of the feeling in his community that he was particularly fitted to treat such conditions. Gradually, a large proportion of his practice was taken up with certain groups of cases—those requiring a special technique in treatment or those suffering from a specific disease. In this way his knowledge of his subject became greater, and he was finally recognized as a specialist in that particular field. Some of these men supplemented their experience with special courses taken in the large hospitals of Europe. Later, as adequate teaching hospitals developed in this country, men with special aptitude in certain fields of medicine, or others who had acquired a considerable experience in some particular field, associated themselves with these hospitals and became teachers in the medical schools as well as specialists in practice.

As the hospital and medical school assumed greater importance in the field of medicine it became the custom for medical graduates to associate themselves with hos-

pitals as interns before entering practice. Selected candidates from this group became assistants to their teachers and instructors, not only in hospital work but in private practice. By constant association with the master these students were prepared to continue as specialists in their chosen fields. This system, when operating at its best, was probably as nearly ideal as could be devised. The candidates were naturally very carefully selected after a long period of observation and were advanced only as they showed ability. They received not only instruction in the *science* of medicine but also in the *art* of medicine, as it is seen in private practice. It was the apprenticeship system carried to the highest degree of development.

Unfortunately, this plan did not produce the number of men necessary for the rapidly increasing demand for specialization, and the increasing growth of the population. Various short-cuts were attempted, the most pernicious of these being the short courses given to the general practitioner who wished to specialize in some field of medicine largely because specialization seemed to offer a more interesting and an easier way of earning a livelihood. These courses reached their highest development in the great teaching hospitals of Europe. As a result of this practice large numbers of inadequately trained men appeared in the various fields of specialized medicine.

Early in the twentieth century, in an attempt to give better service to the ward patients and to relieve, to some extent, the overworked visiting staff, hospitals began to establish residencies in medicine and surgery, and somewhat later in the medical and surgical specialties. These residents, selected from the interns, continued their work in the hospital for varying periods of time, usually a year or more, the hospital supplying board and room, and in some instances a small salary. The duties of the resident were similar to those of a junior member of the staff. This movement had a rapid growth and is now generally accepted in all teaching hospitals. The number of residents on each service has in-

creased and practically all specialties are now represented. The residency system has supplemented, and to some extent replaced, the apprentice or assistant system. Its advantages over the older method are first, that it increases the number of men trained, and second, that the present-day resident receives a better training in the scientific aspects of medicine than did his predecessor, the assistant to the specialist in private practice. Its disadvantages are that the selection, while good, is not as personal as in the older system, and the student lacks training in the *art* of medicine, which can be obtained only in private practice.

In 1916, the Mayo Foundation established fellowships in medicine leading to a master's degree. This course of training included the residency, and, in addition, special training in the fundamental sciences with periodic examinations and the writing of a thesis. If the student's work was satisfactory, he was awarded a diploma. This idea, with various modifications, has been adopted in several of our larger universities. The principal objection to the plan is financial. At the Mayo Clinic the scholarships are adequately financed, but in some institutions only two years of the course, that part devoted to the residency, can be properly financed. Until a sufficient number of endowed fellowships are available the general adoption of this excellent plan is doubtful.

From this brief review it is obvious that the character of training received by physicians, holding themselves out to the public as specialists in the various fields of medicine has differed widely in methods and results. We have, first, the general practitioner, who on his own initiative decided to become a specialist and who has received inadequate training through short courses, second, the hospital resident who has had from one to two years of training in a hospital more or less equipped for such training, and lastly, the Fellow who has had three years of supervised work in an institution especially adapted for such training. As a result many poorly trained "special-

ists" have been produced. For some time there has been a concerted effort on the part of organized medicine, and of the general public, to establish standards to which any physician specializing in any branch of medicine should conform.

In some States plans were made to establish licensing boards for the examination of specialists similar to the State licensing boards in general medicine. It is the feeling of organized medicine that this is not the answer to the problem. It may well be the function of the State to determine whether or not a physician may safely practise the "healing art" within its borders, but it is not its function to determine whether or not he possesses the special qualifications required of a specialist. This function belongs in the hands of his fellow-physicians. To prevent the growth of this movement on the part of the State, and to establish standards to which all specialists should conform, examining boards in the various specialties were established. The personnel of these boards is selected from the national societies representing the specialty, and the board receives its authority through the Council on Medical Education and Hospitals of the American Medical Association. Uniform standards throughout the various special fields, including certain requirements as to previous training before a candidate is accepted for examination, have been adopted. A successful candidate is given a certificate stating that the Board recognizes him as a specialist in his chosen field. The examination is not obligatory. A physician not holding a certificate is not prevented from practising in the specialties. He is not, however, listed as a specialist in the *Directory of the American Medical Association*, and his promotion in hospitals and universities is regulated to some extent. Furthermore, those candidates receiving certificates comprise a list from which physicians or patients seeking a specialist may choose.

The establishment of such examining boards has made it necessary to develop more uniform and definite methods of

training physicians in the various specialties. If these boards are to demand certain standards of training and education before an applicant may be accepted for examination, they must, in turn, supply the facilities by which candidates in sufficient numbers to meet the demand in the various cities and towns may receive such training.

The American Medical Association lists 1,522 physicians in the United States as specializing in radiology, and probably there are as many more unlisted. The American Board of Radiology has received applications from 1,139 physicians, and has issued certificates to 849 radiologists.¹ It is safe to assume that there are at least 3,000 physicians practicing radiology in the United States at the present time. The life expectancy at the age of 30 years, when most candidates begin their work in a special field, is estimated at 35 years, which coincides with the usual retirement age of 65. This seems to place the maximum years of active practice in a specialty at between 30 and 35 years. The annual death rate of the adult population of the United States for all ages above 19 years is 15.7 per 1,000. To maintain the present number of physicians listed as practicing radiology as a specialty it is, therefore, necessary to bring into the field annually at least 70 new men. If the number of men practicing radiology is placed at 3,000, which is more probable, the number of men available each year should be doubled. This number would not take care of any increase in demand, nor of any vacancies created by men who for various reasons leave the specialty.

In the "Journal of the American Medical Association," Aug. 29, 1936, Vol. 107, there is a list of hospitals in the United States approved by the Council on Medical Education and Hospitals of the American Medical Association for residencies in the specialties. Fifty-three approved hospitals offer residencies in radiology. It is probable that this estimate is large rather than small. If we accept the statement

that there are 53 hospitals in the United States offering satisfactory residencies in radiology, and assume that the course of training is at least two years, also that the average hospital can accommodate two residents, the possible number of new radiologists available annually would not be over 53. If the course of residency is raised to three years, as has been suggested, this number would be materially reduced.

From the figures just quoted it is obvious that the facilities for training radiologists are already inadequate, and that any raising of standards must, therefore, be accompanied by increased facilities for the training of candidates. Any plan which is adopted must utilize to the fullest the present teaching facilities as well as any new fields which may become available. Also, it should offer opportunity for additional training to the younger men already specializing in radiology, who are not able to meet the requirements of the examining boards. Since success in a specialty, particularly in radiology, is definitely dependent upon constant study and the acquiring of new knowledge, the plan should recognize this fact by offering "refresher courses" at the great medical centers for those specialists located in the smaller towns where advanced information is not easily available.

From this review of past and present methods of teaching in radiology, the problem can be visualized and certain recommendations as to future methods of teaching may be made. We should maintain at least three thousand properly trained specialists in radiology in the United States. Any smaller number will be insufficient to meet the public need, and as a result inadequately trained men will take this opportunity to establish themselves in the specialty. At least two types of men are necessary, each possibly requiring somewhat different training. First, there is that great group of roentgenologists who carry on the bulk of the routine work in our smaller hospitals and in private practice. Second, there are those men, leaders in our specialty, who are to do the

¹ June 1937

teaching and research work. The latter are usually located in the large teaching centers and their number is much smaller than that of the first group.

The demand for teaching, therefore, naturally divides itself into three groups: first, the so-called "refresher courses" for those men already in the field, second, opportunity for adequate training of the men who are to do the routine work of the specialty, and third, the development of such courses as will attract to this specialty some of the best minds among the younger generation in medicine, and will afford them ample opportunity to develop as teachers and investigators in their chosen field.

We should recognize in the consideration of our problem certain principles in teaching which have come down to us from the past. First, there is the didactic method of instruction—the direct transmission of knowledge from teacher to pupil. The pupil asks a question and the teacher answers it, either directly or by means of lectures. This is the method adopted to a large extent in our public schools and is most successful in the teaching of children. It is natural for children to ask questions and to expect a positive answer. This method has also been successfully used in the preparation of large numbers of men to meet certain definite requirements. The student is equipped with facts which allow him to accomplish a given task. He is not, however, prepared for the acquisition of knowledge on his own initiative, and if the didactic method is carried too far it may actually hinder his development.

The second method of teaching is by experimentation and discussion. This may well be called the "adult method." There is a time in the life of every boy when he ceases to be satisfied with having his questions answered by an instructor, when he prefers or insists upon finding out these things for himself. When this age is reached the didactic method of instruction is no longer helpful. If the student is to reach his highest development, he must be given an opportunity to investigate for

himself under supervision. This age probably varies considerably with the individual, but it is safe to assume that between the ages of 25 and 30, when most men begin their studies in the specialties, they have passed the time when methods of instruction adapted to childhood teaching should be used, and are ready for one which puts them more or less on their own initiative. The method of choice should be one which teaches them to think correctly and to master each problem as it arises by individual study and experimentation.

Most thinking men agree that to build on the acquired knowledge of the past is better than to attempt revolution. Older methods should be improved, the good retained and the bad discarded, they should not be replaced by new, untried systems.

A proper course of instruction to meet our requirements should, I believe, be based upon the hospital residency rather than upon the so-called "post-graduate medical school." The candidate should be selected by the hospital for the position of resident before he is allowed to matriculate at the university. In no other way will the most important part of our program be carried out, namely, the selection of the candidate and the certainty that he will receive the required training in the clinical aspects of the specialty. Advanced training in the fundamental sciences, examinations, and the writing of a thesis leading to a degree may well be the function of the university, but these things are secondary to the careful selection of the candidates themselves and their training in the clinic.

The Executive Committee of the Massachusetts General Hospital appointed a sub-committee to arrange a program of instruction for residents in the specialties to meet the requirements of the examining boards. This committee met on Oct. 29, 1936, at which time the recommendations of the Advisory Board on Medical Specialties, as published by their secretary, were discussed. It was generally agreed that the various departments at this hospital should conform, as nearly as possible, with these recommendations. Each department head

was instructed to prepare a plan for his own particular department which, in his opinion, would be satisfactory to meet the requirements

After reviewing the material submitted by the various heads of departments and discussing the problem with teachers in other universities, as well as at Harvard, it was agreed that a course of instruction for specialists to meet the requirements of the examining boards should be based on our present method of teaching, namely, the hospital residency, rather than the establishment of a school for post-graduate teaching, and the following program was suggested

"The course for residents at this hospital should be for one or more years as at present. The appointment, to be made annually, should preferably consist of a junior and a senior year, to which should be added one year as graduate assistant, house officer, or research fellow. The appointment as graduate assistant should preferably come before the residency, that of research fellow should preferably come after the residency

"The graduate assistant would live outside the hospital, receiving no compensation. During the year he should take the basic sciences prescribed, and to this should be added a certain amount of work in the department of the hospital to which he is assigned. It might also be arranged to accept men as residents who have had this course in another institution, or who had served one year as house officer in the same department. Men selected for graduate assistants would naturally be those who, after completing their general internship, had had some additional work either in private practice or in the specialty

"The work of the resident would be practically the same as at present, with the possible addition of special courses to complete his work in the basic sciences

"The work of the research fellow would be a continuation of the work as resident. A research fellow would live outside the hospital and receive a maintenance salary, preferably from an endowment fund especially for such scholars. It is also possible that he be given a teaching position in the medical school with a small salary or that he receive a small salary from the hospital. During this period of service he would act as assistant in the department to which he was assigned and carry on some form of investigative work. He should be given sufficient free time to take courses in the

basic sciences necessary to complete his work. These fellows would naturally be selected from the residents, but could be transferred from other institutions. They should be urged to prepare a thesis and to appear before an examining board for a master's degree

"A plan such as this has several advantages. First, it does not interfere, materially, with our present plan, which has been satisfactory in the past. Second, it is flexible. Third, it provides for the two classes of physicians who are likely to apply for such training, namely, the man who after completing his internship enters private practice, and later decides to take up a specialty, and the man who intends to enter a specialty from the start and who wants to prepare himself to become a leader in his field."

Columbia University has also established a program of graduate medical education from which I quote

"Proper training for a specialty includes three major phases. The first is a sound basic medical education, including a hospital internship, which is now regarded as part of that preparation. The second is advanced training in those medical sciences which are concerned particularly with the limited field of the specialty. The third phase is a long active clinical experience as a resident in a hospital equipped and staffed to provide graded responsibilities under the supervision of experts in the field of medicine selected."

They further state that

"after full consideration of the great importance to the medical profession, the hospital, and the public, of establishing graduate medical education at a high university level, the trustees of the university have created a higher degree to identify the individuals who obtain that recognition. Only residents holding an appointment in one of the affiliated hospitals are eligible for registration for the degree. Such residents are appointed by the hospital on the nomination of its own staff, as in the past. Those with proper qualifications who wish to register for the degree and are on a service approved by the university for the purpose may do so on the recommendation of the executive office of the department concerned. Each candidate will be expected to spend a part of his residency, or a period preceding it, in the medical sciences, present a program of scientific studies, write an acceptable thesis, and present himself for an examination in the field of study elected."

This plan, as in the one I have just outlined, permits the hospital to select the

teaching and research work. The latter are usually located in the large teaching centers and their number is much smaller than that of the first group.

The demand for teaching, therefore, naturally divides itself into three groups: first, the so-called "refresher courses" for those men already in the field, second, opportunity for adequate training of the men who are to do the routine work of the specialty, and third, the development of such courses as will attract to this specialty some of the best minds among the younger generation in medicine, and will afford them ample opportunity to develop as teachers and investigators in their chosen field.

We should recognize in the consideration of our problem certain principles in teaching which have come down to us from the past. First, there is the didactic method of instruction—the direct transmission of knowledge from teacher to pupil. The pupil asks a question and the teacher answers it, either directly or by means of lectures. This is the method adopted to a large extent in our public schools and is most successful in the teaching of children. It is natural for children to ask questions and to expect a positive answer. This method has also been successfully used in the preparation of large numbers of men to meet certain definite requirements. The student is equipped with facts which allow him to accomplish a given task. He is not, however, prepared for the acquisition of knowledge on his own initiative, and if the didactic method is carried too far it may actually hinder his development.

The second method of teaching is by experimentation and discussion. This may well be called the "adult method." There is a time in the life of every boy when he ceases to be satisfied with having his questions answered by an instructor, when he prefers or insists upon finding out these things for himself. When this age is reached the didactic method of instruction is no longer helpful. If the student is to reach his highest development, he must be given an opportunity to investigate for

himself under supervision. This age probably varies considerably with the individual, but it is safe to assume that between the ages of 25 and 30, when most men begin their studies in the specialties, they have passed the time when methods of instruction adapted to childhood teaching should be used, and are ready for one which puts them more or less on their own initiative. The method of choice should be one which teaches them to think correctly and to master each problem as it arises by individual study and experimentation.

Most thinking men agree that to build on the acquired knowledge of the past is better than to attempt revolution. Older methods should be improved, the good retained and the bad discarded, they should not be replaced by new, untried systems.

A proper course of instruction to meet our requirements should, I believe, be based upon the hospital residency rather than upon the so-called "post-graduate medical school." The candidate should be selected by the hospital for the position of resident before he is allowed to matriculate at the university. In no other way will the most important part of our program be carried out, namely, the selection of the candidate and the certainty that he will receive the required training in the clinical aspects of the specialty. Advanced training in the fundamental sciences, examinations, and the writing of a thesis leading to a degree may well be the function of the university, but these things are secondary to the careful selection of the candidates themselves and their training in the clinic.

The Executive Committee of the Massachusetts General Hospital appointed a sub-committee to arrange a program of instruction for residents in the specialties to meet the requirements of the examining boards. This committee met on Oct 29, 1936, at which time the recommendations of the Advisory Board on Medical Specialties, as published by their secretary, were discussed. It was generally agreed that the various departments at this hospital should conform, as nearly as possible, with these recommendations. Each department head

younger generation of physicians and to offer them opportunities for prolonged training and research under the most favorable conditions. We have an abundance of clinical material which is rapidly being organized for teaching. Our greatest need is endowed university fellowships to the end that our present residencies may be sup-

plemented by courses in the basic sciences leading to a master's degree.

Much progress has already been made, and I am sure that a satisfactory program will soon be completed. The future of radiology was never more promising than at the present time.

candidate and to supply him with clinical experience. The university supervises his instruction in the basic sciences and permits him to try for a master's degree if he so desires. If such a plan were generally adopted, our problem would be relatively simple. It would be necessary only to add to our present system of residents, a certain number of endowed university fellowships so that no man of ability would be unable to complete his training because of lack of funds.

It would not be necessary for the student to receive all of his clinical instruction at one hospital. There are many hospitals in this country where splendid training in certain branches of radiology may be obtained, but in which a complete course in the subject would not be available. This is particularly true of the highly specialized hospitals. A candidate while serving an internship in this type of hospital might accumulate credit in the basic sciences at an affiliated university. It is not necessary that clinical experience be obtained in hospitals only. Time spent as an assistant in private practice with some of our leading radiologists might well be of equal or greater value to similar time spent as a hospital resident. The examining boards in the specialties should not be too specific in stating the requirements for examination by the boards. More responsibility should be placed upon the student, and he should be allowed to acquire credit from all recognized sources. The procedure for the training of the candidate for specialization in radiology might well be as follows: after graduation from a "Class A" medical school he should have at least one year's internship in a recognized hospital. This should preferably include both medicine and surgery. He should then apply for a residency in radiology in a well equipped teaching hospital. If his personality and qualifications are of the best, he may hope to obtain a residency in an institution which offers a three-year course including a fellowship covering the basic sciences and leading to a university degree. If he is unable to obtain such an appointment, he

may accept a residency in a hospital offering a two-year course as resident. This may be followed by a residency of a shorter period in another hospital, preferably one which offers special training in some branch of radiology, during which time he may take the basic science courses in an affiliated university, or, after completing a certain period as hospital resident, he may associate himself with a radiologist in private practice as an assistant, during which time he will receive additional clinical training and take courses in the basic sciences. In this way it would even be possible for him to accumulate a sufficient number of credits which, with the presentation of a thesis, would justify the awarding of a master's degree by a university. Whatever the plan adopted, the details should be worked out by the individual hospitals and universities. Broad principles only should be laid down by the examining board. It is of the greatest importance that the plan shall permit of the training of a sufficient number of men to meet the demands of the community, that it shall utilize to the greatest extent our present facilities for teaching, and that the selection of candidates shall be adequately supervised. Any plan which does not recognize these general principles will defeat itself. It is my firm belief that much of our present trouble is due to the presence in radiology of poorly selected, inadequately trained men.

When we, as radiologists, include in our ranks a fair percentage of the great leaders in medicine, we will have no further difficulty with hospital boards and the general medical profession. Radiologists have, in the past, contributed much to our general knowledge of the diagnosis and treatment of disease, but this progress has been made by a relatively small group, and many of the great advances in our specialty have been made by other than radiologists.

If we are to take our proper place among the leaders in the advancement of medical science, it is necessary to attract to our specialty some of the best minds in the

shadow of the organ. We may, in this way, recognize abscesses, cysts, metastatic areas, and cirrhosis, by alterations from

served for a period of six years still showed no evidence of the regenerative type of pernicious anemia, nor any bone malignancy.

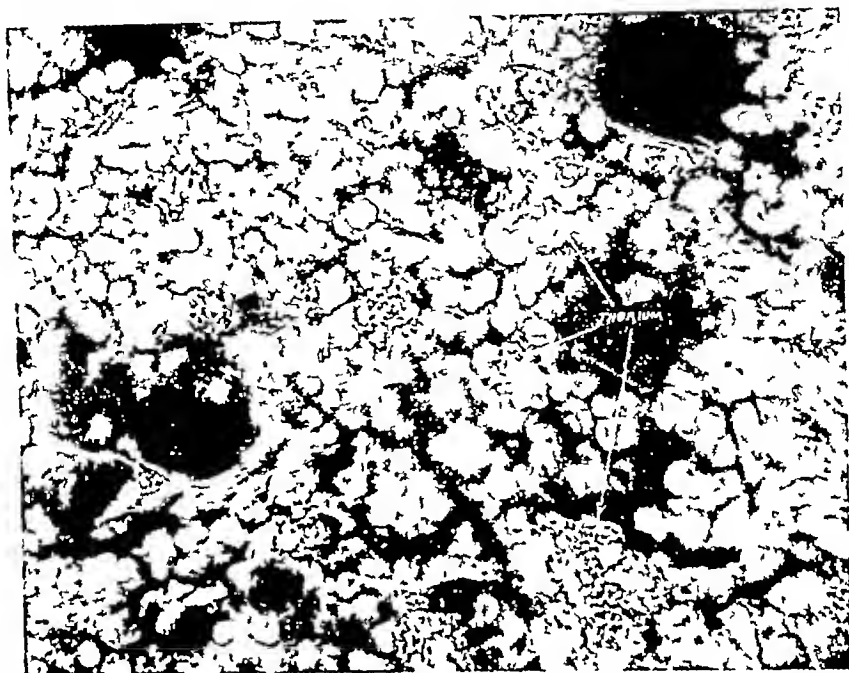


Fig 1

the normal appearance of the shadows. Observation on a patient who retains thorium for a long period shows, even in normal subjects, a granular appearance in the liver and spleen shadow due to absorption and re-absorption of the thorium. Its transmission to the regional hepatic and other intra-abdominal glands may be observed. This redistribution of the thorium suggests that its absorption is not a stable process.

Thorotrast (Heyden) is the commercial name for the colloidal thorium introduced as an opaque substance for the visualization of the reticulo endothelial system. Its merits are so well known and so well established by recent experimental and clinical work, that any listing of its advantages now would be superfluous. Still unanswered, however, is the question of its potentialities as a hazard to the hematopoietic centers arising from late radio-activity, because of poor elimination of the thorium. We do know, however, that patients ob-

served for a period of six years still showed no evidence of the regenerative type of pernicious anemia, nor any bone malignancy. This has been reported by Martland (3) in his study of luminous dial workers.

Dosages now employed in clinical work have been reduced to a minimum. For visualization of the liver and spleen, from 25 to 40 c c are used. We are, at present, chiefly concerned with the introduction of even smaller amounts of thorotrast for the localization of disease. For this purpose we are using from 2 to 15 c c. The minimum dose (from 25 to 40 c c) needed for the visualization of the liver and spleen amounts to about 0.45 to 0.72 microgram of radio-active material, as computed by Taft (4). This should be used only in elderly patients, and then only when malignancy or other serious disease is present. Smaller doses of thorium (from 2 to 15 c c) may be used without hesitation in any case warranting its administration for diagnostic purposes, when other methods have failed. This dosage (from 2 to 15 c c) amounts to only 0.036 to 0.27 microgram of radio-active material. The peritoneum, pleura, nerves,

COLLOIDAL THORIUM IN THE LOCALIZATION OF DISEASE¹

FURTHER EXPERIMENTAL DATA IN BONE TRAUMA AND INFECTION

By RAPHAEL POMERANZ, M D, Newark, N J

THE retention and localization of colloids injected into the blood stream are determined by factors similar to those which condition the localization of blood-borne diseases. These factors are, according to Burrows (1) (1) Abnormal permeability of the walls of the small blood vessels, (2) forces capable of transmitting the noxious agents through the endothelial cytoplasm, and (3) retention of noxious agents in the tissues under the influence of inflammation. An electro-negative foreign substance, whether in colloidal form or not, will be removed from the blood stream by the reticulo-endothelial system, and its cells in the liver, spleen, bone marrow, and other organs. This process of permeation—or “diaporesis” as Burrows (1) calls it—will be further modified by other conditions, such as inflammation, concentration of hydrogen ions in the blood or extravascular tissues, conductivity of cells, ischemia, congestion, general shock, or body antigen reaction.

The present discussion will be limited to the use of colloidal thorium as the agent capable of visualizing reticulo-endothelial tissues, and to the value of this process in the localization of some diseases, with special reference to trauma and inflammation of bone.

Aschoff (2) introduced the term “reticulo-endothelial system” to describe a group of cells of mesenchymal origin, characterized by two common properties—phagocytosis and vital staining. These cells line the blood and lymph sinuses and are found chiefly in the liver, spleen, bone marrow, and lymph nodes, and to a lesser extent in the adrenals, hypophysis, and lungs. The distribution of these special cells is wide in area and diversified in form. Spleen and

liver contain the largest amount, followed, in order, by the bone marrow, lymph nodes, omentum, serous cavities, lungs, suprarenal capsules, and pituitary body. The principal functions of these cells are phagocytosis, storage, and formation of antibodies, and the destruction of blood cells. However, these tissues also play a rôle in the defense mechanism of the body by promoting the elimination of bacterial toxins, cell products, and other poisons introduced into the blood stream. The reaction of the reticulo-endothelial system to disease is manifold. In acute infection the response is temporary phagocytic hyperplasia or the formation of antibodies. In some chronic infections, it produces a new type of cell from the histiocytes, forming granulation tissue. This occurs in tuberculosis, Hodgkin's disease, and the granulomas. In other chronic diseases, it responds with abnormal hyperplasia and excessive storage capacity as, for example, in Niemann-Pick's disease, or in the Schuller-Christian syndrome.

The roentgen visualization of an organ by means of thorium depends on the number and behavior of its reticulo-endothelial cells. This visualization may be accomplished by two methods—saturation and selective infiltration. The saturation of an organ with thorium may be partial or complete. Spleen and liver, for example, containing large numbers of reticulo-endothelial cells, will retain the bulk of the injected thorium—the spleen, as a rule, holding relatively more than the liver. By visualization in this manner, we can define the size, shape, and position of the organ. Any pathologic change which will destroy or replace parts of the liver or spleen, and thus destroy or replace parts of the reticulo-endothelial cell system, will be seen as a translucency in the otherwise homogeneous

¹ Presented before the Fifth International Congress of Radiology in Chicago, Sept. 13-17, 1937.



Fig 3 See caption under Figure 2

sions of bone by intravenous or intraperitoneal injections of small amounts of thorium. For this purpose the following experiments were performed

EXPERIMENTAL WORK

A number of rabbits of about the same age, each weighing between three and four pounds were used. Having traumatized

the tibia or femur or both, we injected 2 c c of thorotrast, either intravenously or intraperitoneally, into each animal. In some of the rabbits, we subsequently in-

dition, a periosteal clouding which was noted 115 hours after the injection. At no time, however, could the cortical wave density described by Solotuchin (5) be found

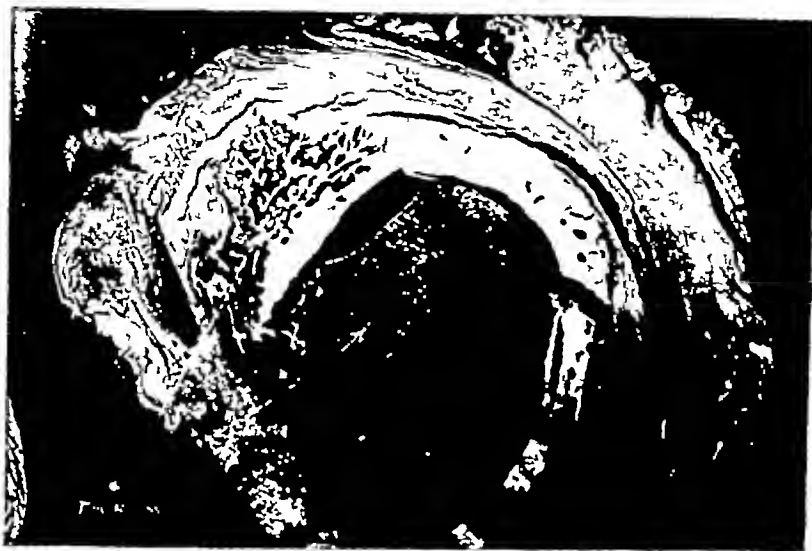


Fig 4 Cross section of tibia (magnification 15 times). Note the large amount of thorium granules in the active fibroblasts of connective tissue forming the soft callus, less in the osteoid tissue and bone marrow, and none in the solid bone.

troduced, locally or intravenously, 0.5 cubic centimeter of a 100 ml suspension of *Staphylococcus aureus*. The trauma was either slight (consisting of pin-point penetration of the bone), or extensive, the latter took the form of comminuted fractures of the tibia or femur.

EXPERIMENT NO 1

Rabbits No 1 and No 5—By means of a very fine needle, several pin-point punctures were made in the tibia and femur. Two days later, we injected 2 c c of thorotrast intravenously. Serial radiographic examinations were made covering the period between the day before the trauma and the autopsy, which was performed 150 hours after the injection of the thorium.

Roentgenographic Findings—The small pin-point bone lesions showed progressively diminished clarity over the point of trauma. About 72 hours after the injection of thorium, a slight haze appeared over the point of the lesion. Rabbit No 1 showed, in ad-

Microscopic Findings—On the healthy side, the thorium granules were uniformly distributed within the reticulo-endothelial cells. On the injured side, the thorium had accumulated in those reticulo-endothelial cells which were found massed near the point of the trauma (Fig 1).

EXPERIMENT NO 2

Rabbit No 2—The injury consisted of comminuted fractures of the femur and tibia. Following this trauma, 2 c c of thorotrast were injected intraperitoneally. The extremities and chest were then serially x-rayed until autopsy, which was performed 17 days after the injection of the opaque medium.

Roentgenographic Findings (Figs 2 and 3)—X-ray examination disclosed multiple fractures of the femur and tibia. In the course of the formation of callus, greater density developed at the point of fractures earlier than might have been expected. At this time, the soft tissues were of unusually

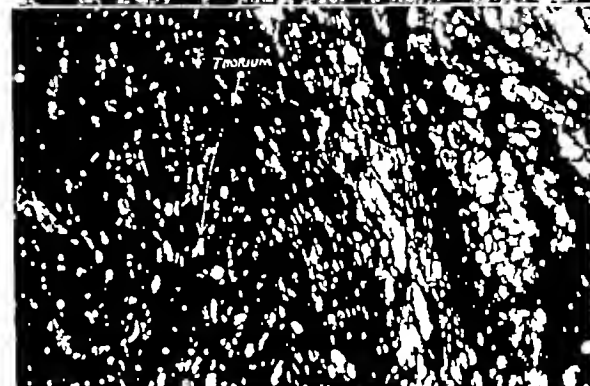
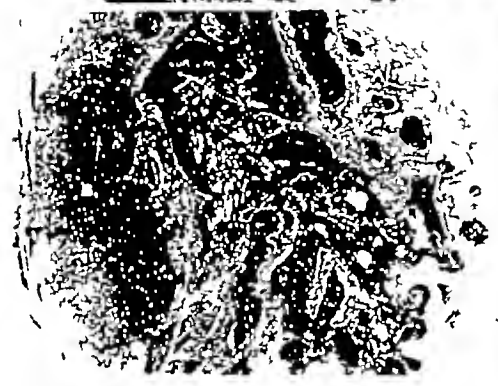
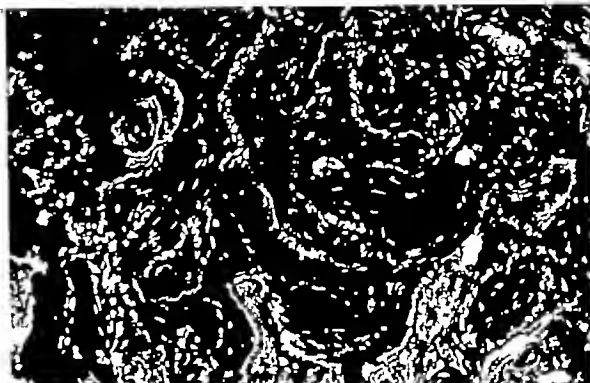
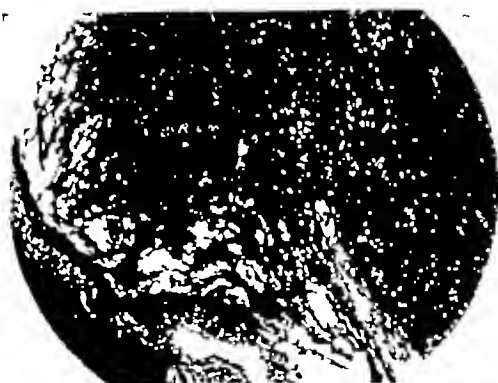


Fig 5

Fig 6

Fig 5 (*Upper*) Thorium in active fibroblasts (*Lower*) (A) solid bone (B) cartilage Neither contains any thorium Note some thorium granules in the osteoid tissue (Magnification 150 times)

Fig 6 Shows the same distribution of thorium as Figure 5 (Magnification 350 times)

granular consistency This was due to the clumps of thorium found on histologic examination

Microscopic Findings (Figs 4, 5, and 6) — Solid bony callus firmly united most of the fragments of the femur In the bone marrow, large clumps of thorium were distributed irregularly within the medullary cavity, chiefly near the fibrous parts of the new formed tissues Wherever the new bone was firm, the amount of thorium was small

EXPERIMENT NO 3

Rabbit No 3 —The trauma consisted of a pin-point lesion combined with a linear, cortical, longitudinal fracture at the lower third of the right tibia Following this injury, 0.5 c.c. of 100 mi suspension of *Staphylococcus aureus* was introduced locally Twenty-four hours later, 2 c.c. of

thorotrast was injected intravenously and, in addition, a gram of silica was injected intraperitoneally Serial x-ray films were taken until the autopsy, on the ninth day after the trauma

Radiographic Findings (Fig 7) —The original pin-point lesion became hazy and was not sharply defined Five days after the injection of thorium, a periosteal reaction was noted which persisted until the last examination, just prior to the autopsy

Microscopic Findings —About the pin-point lesion, the distribution of thorium in the bone marrow was analogous to that previously described At the point of visualized periosteal reaction, a linear accumulation of thorium was seen In this rabbit, a bronchopneumonic focal lesion developed in the lungs Under high power, a number of very fine thorium granules were seen in the phagocytes (Fig 8)

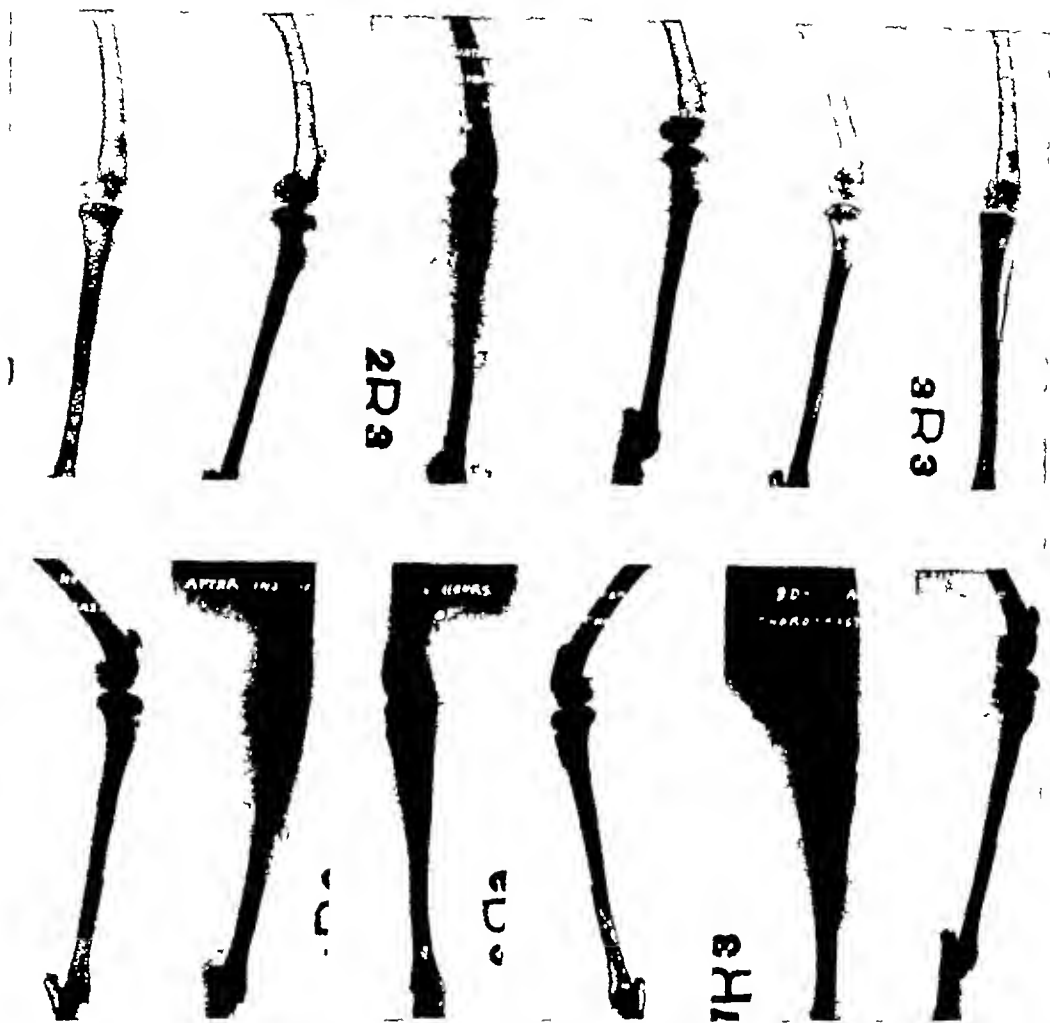


Fig 7 Serial radiographic follow up of Experiment No 3

EXPERIMENT NO 4

Rabbit No 4—The trauma consisted of a pin-point lesion of the tibia. Two days later, 0.5 cc of 100 mi suspension of bacteria was injected intravenously and 2 cc of thorotrast was administered intraperitoneally. Radiographic and microscopic findings were similar to those described in Experiment No 1.

COMMENT

The microscopic findings in these experiments reveal that the thorium particles are evenly distributed in the uninjured extremity. On the other hand, the particles accumulated in large amount at the point of the lesion on the injured side. This was

most clearly demonstrated in rabbit No 2 (Experiment No 2) in which the fractures were extensive. The distribution of thorium in the cells during the stage of callus formation is of particular interest. One can see a large number of thorium granules accumulated in an irregular manner in the active fibroblasts and histiocytes chiefly around the small capillaries and in the periosteum of the injured area. In cases in which the bone is intact, the periosteum shows practically no thorium. The corresponding area of bone marrow shows a rather uniform distribution of the thorium. On the site of the injury, the amount of thorium is almost three or four times as great. The newly formed cartilaginous

tissue shows practically no thorium. Whenever osteoid tissue is formed, thorium rapidly diminishes in amount. The osteoblasts show no evidence of thorium whatsoever. Occasionally some thorium granules in the newly formed bone can be seen. As a whole, however, most of the thorium has disappeared. It appears as if the bulk of the thorium has been taken up again by the new capillaries and carried away to other places.

It is obvious the smaller the lesion, the less the reaction, the fewer the accumulated reticulo-endothelial cells, and, therefore, the relatively less thorium. At no time was an effect on the general health of the rabbits observed. The bulk of the thorium was retained in the liver and spleen in each case. In rabbit No 3, an infectious focus of infiltration was produced with the help of bacteria. In this instance many phagocytes were noted, but no significant amounts of thorium were associated with these cells. This may be explained by the following hypothesis: before the focus developed, all the thorium had already been absorbed by the reticulo-endothelial cells of the other organs, so that very little of it filtered through from the blood stream into the lung lesion. Further experimental study of inflammatory lung lesions is, therefore, needed and would be of great theoretical value.

Roentgenographic findings in all our experiments show lack of clearness and increased density of the injured area sooner than otherwise expected, usually 72 hours after the injection. Occasional periosteal clouding and even early periosteal apposition can be noted which apparently are due to local deposits of thorium. In our experiments we were unable to produce the wave-like density described by Solotuchin, which may be attributed to change in our technic, the site of the injection and the interval of the x-ray examination were different from his experiments.

SUMMARY AND CONCLUSIONS

1 Colloidal thorium is an excellent medium for the experimental visualization

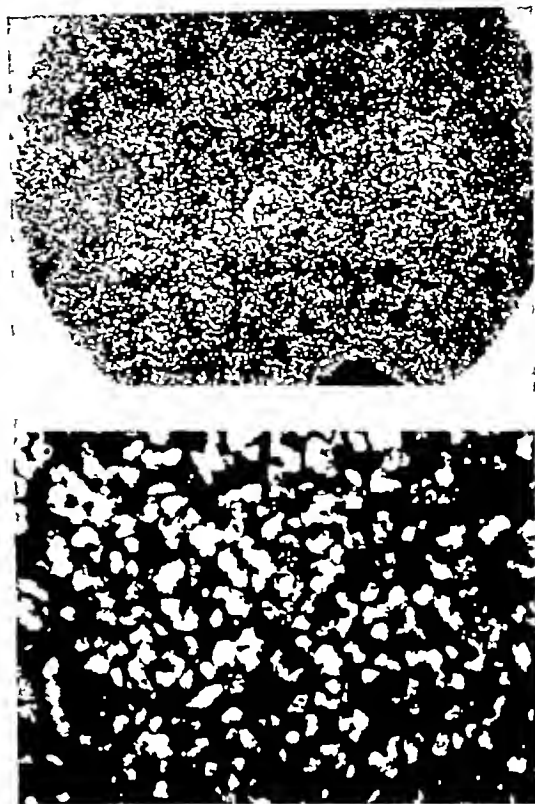


Fig 8 Thorium granules in phagocytes of an artificially produced focal bronchopneumonic lesion (Upper shows low power, lower shows high power magnification)

and study of the reticulo-endothelial system in health and disease

2 Its clinical use in human adults should be restricted to those cases in which its lifelong retention is not hazardous, *e g* in malignancies, leukemia, and similar conditions

3 When used in this manner, it should be critically evaluated by the microscopic study of tissues obtained at autopsy in a large series of cases collected over a period of years

4 Animal experimental work with small doses of thorium for the visualization of small infectious bone lesions is valuable for the study of reticulo-endothelial cells under the influence of inflammation

5 Judgment as to the clinical use of such doses in human beings must be withheld until more extensive experimental data are secured. In the intravenous use of thorium, one should heed the warning of

Martland (3) and other investigators, not to increase the radio-activity of the human body because of the danger of late induction of bone malignancies. The elapsed time of seven years is insufficient as a criterion of its safety.

In conclusion, I wish to thank Dr H S Martland for his kind help in preparation of the photomicrographs. I also wish to express my appreciation to I R Asen, chemist, and his co-worker, for their able assistance, as well as to the Heyden Chemical Co. for the supply of thorotrast used in these experiments.

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MEASUREMENT OF ROENTGEN-RAY DOSAGE BY DETERMINING THE EFFECT OF RADIATION ON CHROMOSOMES

By ALFRED MARSHAK, PH D, Laboratory of Pathology, N E Deaconess Hospital and
J CRAMER HUDSON, PH D, Collis P Huntington Memorial Hospital, Boston

WHILE the generally accepted method of measuring roentgen-ray dosage is by means of ionization chambers, the use of biological test objects also is of considerable importance since the radiologist is primarily interested in the biological effects of radiation. However, if the desired relationship between the biological unit of effect and the roentgen is to be known, it is necessary that the biological response used be independent of wave length within the range of wave lengths used or that the function relating response and wave length be known for every dose. Obviously for radiation generated at voltages in the neighborhood of 1,000 kv the necessary conditions cannot be fulfilled at present, since there is no accepted method of measuring dosage in roentgens at these high voltages. Consequently it is desirable that the biological response studied be one which is fundamental to all organisms, since only under such circumstances can experimental results obtained with one organism be used as a basis of prediction of effects in others. It is particularly significant if the response can be related to one type of reaction which is desired in the treatment of neoplastic disease. Chromosome division is a process which has been shown to have quantitatively similar characteristics in all the different plant meristematic tissues and mammalian tumors studied thus far (28). Therefore the production of chromosome

abnormalities should serve as a suitable means of quantitative dosage measurement. Several other biological objects and processes have been studied by various investigators and some of these will be mentioned briefly after the presentation of the data.

PROCEDURE

Three different qualities of radiation were used in the present experimental work, the first generated at 120 kv, the second at 180 kv, and the third at 400 kv. The first two were generated by a Westinghouse quadroconex machine, using a tungsten tube with a large thin target. The third type of radiation was generated by a General Electric 400 kv machine, using an oil-cooled roentgen-ray tube. Both these machines are installed in the Palmer Memorial Hospital, Boston.

The conditions of operation of the machines are shown in the accompanying Table I.

All voltages are measured by means of a spark gap. The filter in the case of the 400 kv machine includes the estimated equivalent copper filter in the tube itself. The intensity in roentgens per minute was measured by means of a Victoreen condenser type r-meter. This meter has been calibrated several times against a standard parallel plate air chamber set up permanently for calibration purposes in the Collis

TABLE I

Kilovolts	Current	Filter	Treatment Distance	Intensity, r/min	Half Value Layer
120	8 ma	5 mm celluloid	54 cm	18.8	4.9 mm Al
180	8 ma	0.5 mm Cu 5 mm celluloid	50 cm	18.1	1.0 mm Cu
400	5 ma	5 mm Cu 0.9 mm Sn 1 mm Al	50 cm	21.5	5.9 mm Cu

P Huntington Memorial Hospital, Boston. At no time did the r-meter show departures from the standard chamber readings of as much as 1 per cent.

In order to have comparable treatment times the intensity of the 400 kv radiation was measured and the conditions for the two other qualities of radiation arranged to give about the same intensity as that from the 400 kv machine. This was in the neighborhood of 20 r per minute. All intensity measurements were taken in air without back-scatter and since the biological material is relatively small and placed on very thin filter paper and cellophane the irradiation is carried out essentially in air without back-scatter.

The quality of the radiation in each case is determined by measuring the half value layer either in aluminum or copper. In these experiments various sheets of aluminum or copper are added and the intensity of radiation determined after the addition of each sheet. By plotting intensity against thickness of added filter the half value layer may be easily determined.

Commercial onion seeds of the variety known as Ohio Yellow Globe, obtained from the Ferry Seed Company, were used throughout this experiment. The seeds were treated with the filtrate from a suspension of bleaching powder, $\text{Ca}(\text{ClO}_2)_2$, for from one to two hours, rinsed several times in sterile distilled water and then allowed to soak for five or six hours in sterile distilled water in a Petri dish. The seeds were then transferred to Petri dishes containing filter papers moistened with sterile distilled water and incubated at 23°C for six days. Seedlings with radicles 1.0 cm or more in length were removed for use in the experiment, the rest returned to the incubator and seedlings again selected on the following day until the supply was exhausted or became infected. Since a single large Petri dish will hold several hundred seeds, a practically continuous supply of seedlings was maintained in this manner with a small expenditure of labor. This was very convenient since the roentgen

machines were available only when not in use for therapeutic purposes.

It is unnecessary for the purposes of this experiment to have the seedlings in any exact stage of development, but it is desirable to have them in a condition which approaches a maximum rate of mitosis in the root tip. Seedlings with roots about one centimeter long or longer may be used up to the stage at which lateral roots appear.

For exposure to the roentgen rays, seedlings were placed between two Whatman No. 1 filter papers of 9 cm diameter held between two sheets of cellophane supported by an ordinary wooden embroidery hoop with a 17 cm inside diameter. The hoop was placed directly on the celluloid filter of the portal in exposures at 180 kv, while at the other two voltages the hoop was held by a ring stand at the required distance from the target of the tube.

After irradiation the seedlings were returned to Petri dishes and incubated for three hours at 23°C . They were then placed in a fixing fluid and a few hours later slides were prepared by a smear technic. If it is more convenient, the material may be left in the fixative for several days. A detailed account of the method of preparation of the slides will be presented elsewhere. It is of interest here to note the fact that it takes little more time to prepare such slides than it does to make blood smears.

The seedlings were exposed to a series of different doses of roentgen rays, and the number of normal and abnormal anaphases in the root tips at three hours after irradiation was determined by microscopic examination using a $10\times$ ocular and a $20\times$ objective. Doubtful cells were examined with this ocular and either a $45\times$ objective or a $90\times$ oil-immersion objective. An abnormal anaphase is defined as one showing one or more attached or fragmented chromosomes. In order to obtain consistent and reproducible results it is necessary to use only the late anaphases in which the distal ends of the chromosomes have become well separated. (Care must be

taken to exclude telophases which can be distinguished by the appearance of the nuclear membrane and of the nuclear lymph and nucleolus) In such late anaphases attached chromosomes can readily be distinguished from those separating normally, while fragments will usually be found lying between the two groups of separating chromosomes in the region of the "metaphase plate" The accompanying photograph (Fig 1), illustrates an attachment and a fragment

In order to determine whether or not there is any significant subjective element entering into the determination of the percentage of unaffected cells, groups of seedlings were irradiated by one of us (J C H), the dose being unknown to the other (A M) The latter then determined the dose from the survival curve (Fig 3) These values were then compared with the dose as measured directly For 120 kv radiation the dose from the curve was 198 r compared with 200 r as measured by the dosimeter, and for 400 kv the values were 203 r and 200 r, respectively This close agreement indicates freedom of the technic from any appreciable subjective error

The results of a number of counts are given in Table II From the data it is evident that there is no significant difference in the percentage of cells which remain normal after treatment with equal roentgen doses at the three qualities of radiation There is an apparent exception in experiment 141, for 400 kv radiation, in which the percentage of normal cells is low In this case, however, a fungus-infected culture was used and in order to have sufficient healthy material the whole mass of seedlings was placed in the roentgen-ray field and the healthy ones selected after exposure and fixation Since such a procedure introduces an obvious error due to scattering, the experiment was repeated using uninfected seedlings which were spread flat upon the filter paper in the usual manner and not massed The values obtained from this lot, Experiment 142, agreed well with those obtained previously at 120 kv and 180 kv

There is another apparent discrepancy between the values of 40 r at 180 kv which gives 88 per cent normal, and the values at 120 kv and 400 kv which give 77 per



Fig 1 Anaphase in *Allium cepa* three hours after receiving fifty roentgens There are a pair of attached chromosomes in the center, while at the left a pair are breaking (by attenuation of a portion of the chromosome) to leave behind a pair of fragments Magnification 1,690 times

cent and 82 per cent, respectively Such a difference of about 10 per cent might be significant However, the values for 40 r at 180 kv were obtained early in the course of these experiments when the roentgen-ray machine was operated only ten or fifteen minutes before the exposure was made Dosimeter measurements made afterward showed that it required half an hour of operation to bring the machine to its maximum steady output The dose as calculated by time of exposure is, therefore, undoubtedly higher than the actual number of roentgens received, and the percentage of unaltered cells is consequently higher than is to be expected from the apparent dose For this reason the difference observed here is not taken to indicate a difference in efficiency of different wave lengths, but to indicate an error in technic

The data may be presented graphically by plotting the percentage of normal cells

P Huntington Memorial Hospital, Boston
At no time did the r-meter show departures from the standard chamber readings of as much as 1 per cent

In order to have comparable treatment times the intensity of the 400 kv radiation was measured and the conditions for the two other qualities of radiation arranged to give about the same intensity as that from the 400 kv machine This was in the neighborhood of 20 r per minute All intensity measurements were taken in air without back-scatter and since the biological material is relatively small and placed on very thin filter paper and cellophane, the irradiation is carried out essentially in air without back-scatter

The quality of the radiation in each case is determined by measuring the half value layer either in aluminum or copper In these experiments various sheets of aluminum or copper are added and the intensity of radiation determined after the addition of each sheet By plotting intensity against thickness of added filter the half value layer may be easily determined

Commercial onion seeds of the variety known as Ohio Yellow Globe, obtained from the Ferry Seed Company, were used throughout this experiment The seeds were treated with the filtrate from a suspension of bleaching powder, $\text{Ca}(\text{ClO}_2)_2$, for from one to two hours, rinsed several times in sterile distilled water and then allowed to soak for five or six hours in sterile distilled water in a Petri dish The seeds were then transferred to Petri dishes containing filter papers moistened with sterile distilled water and incubated at 23°C for six days Seedlings with radicles 1.0 cm or more in length were removed for use in the experiment, the rest returned to the incubator and seedlings again selected on the following day until the supply was exhausted or became infected Since a single large Petri dish will hold several hundred seeds, a practically continuous supply of seedlings was maintained in this manner with a small expenditure of labor This was very convenient since the roentgen

machines were available only when not in use for therapeutic purposes

It is unnecessary for the purposes of this experiment to have the seedlings in any exact stage of development, but it is desirable to have them in a condition which approaches a maximum rate of mitosis in the root tip Seedlings with roots about one centimeter long or longer may be used up to the stage at which lateral roots appear

For exposure to the roentgen rays, seedlings were placed between two Whatman No 1 filter papers of 9 cm diameter held between two sheets of cellophane supported by an ordinary wooden embroidery hoop with a 17 cm inside diameter The hoop was placed directly on the celluloid filter of the portal in exposures at 180 kv, while at the other two voltages the hoop was held by a ring stand at the required distance from the target of the tube

After irradiation the seedlings were returned to Petri dishes and incubated for three hours at 23°C They were then placed in a fixing fluid and a few hours later slides were prepared by a smear technique If it is more convenient, the material may be left in the fixative for several days A detailed account of the method of preparation of the slides will be presented elsewhere It is of interest here to note the fact that it takes little more time to prepare such slides than it does to make blood smears

The seedlings were exposed to a series of different doses of roentgen rays, and the number of normal and abnormal anaphases in the root tips at three hours after irradiation was determined by microscopic examination using a $10\times$ ocular and a $20\times$ objective Doubtful cells were examined with this ocular and either a $45\times$ objective or a $90\times$ oil-immersion objective An abnormal anaphase is defined as one showing one or more attached or fragmented chromosomes In order to obtain consistent and reproducible results it is necessary to use only the late anaphases in which the distal ends of the chromosomes have become well separated (Care must be

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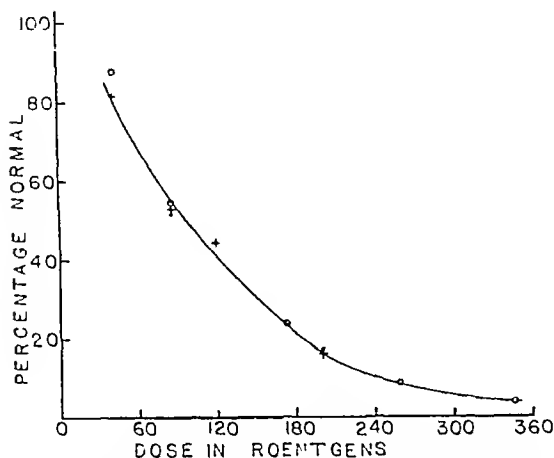


Fig 2 The percentage normal anaphases as a function of dose in roentgens. Open circles denote points obtained with radiation at 180 kv, closed circles 120 kv, and crosses 400 kv.

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DISCUSSION

The data presented show that the material studied is markedly sensitive to radiation, 40 roentgens being sufficient to produce about 20 per cent effect. This is a considerably higher sensitivity than many of the materials used to measure biological response *e g*, *Drosophila* eggs (14, 15, 29), *Ascaris* eggs (3, 18, 41), wheat, lettuce, and lentil seedlings (15, 37), yeast (11, 20), bacteria (19, 21, 24, 39), fungi (36), protozoa (4, 35), gene mutation (12, 13, 30), tissue cultures (23, 32, 33, 34), fern spores (40), and others. Comparable sensitivities have been reported for *Axolotl* eggs (26) and for root elongation in *Vicia faba* (9, 10, 25). Results of these experiments indicate a very low biological variability as compared to the other processes and organ-

isms and because of this low variability and marked sensitivity, the production of chromosome abnormalities in such material as

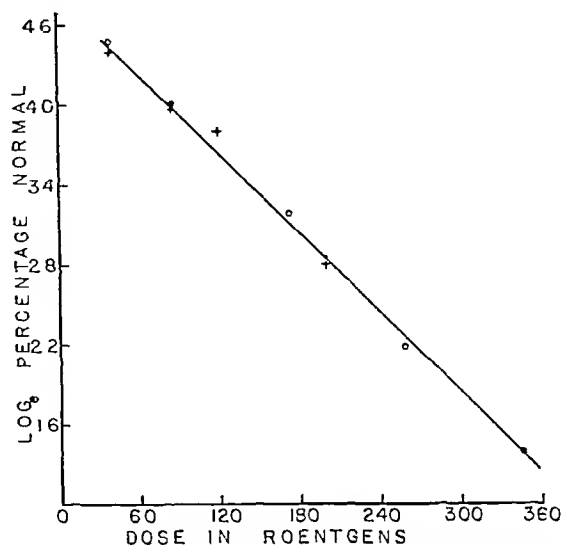


Fig 3 The natural logarithms of the percentage normal cells as a function of dose in roentgens. Closed and open circles and crosses have the same significance as in Figure 2.

the root of the onion seedling makes a very satisfactory biological indicator of roentgen-ray dose.

There are other important advantages also. The seed is cheap and readily obtained, is easily germinated, and the response to radiation remains constant throughout the year. The response measured is not subject to diurnal variations such as have been demonstrated for the frequency of mitoses and root elongation (9, 37). The response can be determined in the relatively short period of a day or two.

Since the curves of the percentage of normal anaphases as a function of dose appear to be identical for the three voltages used there is apparently no wave length dependence within that range. It would seem, therefore, that this would make quite desirable material for the study of depth doses in a phantom. Before making such a study, however, it would be necessary to extend the study of wave length dependence much further into the soft roentgen-ray region, which may quite readily

TABLE II

Dose in Roentgens	Voltage kv	Experi- ment No	Slide No	Normal	Abnormal	Total No	Percentage Normal
40	180	69	558	269	29	298	90.3
		71	562	40	6	46	87.1
		103	736	105	15	120	87.5
			737	272	46	318	85.5
			Totals	686	96	782	87.8
86	180	64	528	148	81	229	64.5
		96	679	135	128	263	51.4
			680	150	156	306	49.1
			Totals	433	365	798	54.4
173	180	68	552	27	111	138	19.6
		99	722	77	221	298	25.8
			723	39	122	161	24.2
			Totals	143	454	597	23.9
259	180	67	551	6	67	73	8.2
		58	511	4	53	57	7.0
		95	676	19	187	206	9.2
			677	10	151	161	6.2
			678	11	110	121	9.1
			Totals	50	568	618	8.8
346	180	94	674	6	89	95	6.3
		100	675	5	87	92	5.4
			724	4	127	131	3.1
			725	9	239	248	3.6
			726	6	181	187	3.2
			Totals	30	723	753	4.0
40	120	140	1-261	413	119	532	77.6
			1-262	325	107	432	75.2
			Totals	738	226	964	76.6
40	400	140	1-264	432	85	517	83.5
			1-265	256	71	327	78.3
			Totals	688	156	844	81.5
86	120	128	1-68	109	104	213	51.2
			1-70	215	198	413	52.1
			Totals	324	302	626	51.7
86	400	128	1-66	192	179	371	51.8
			1-67	131	111	242	54.1
			Totals	323	290	613	52.7
120	120	140	1-257	50	69	119	42.0
			1-258	125	146	271	46.1
			1-259	192	243	435	44.1
			Totals	367	458	825	44.5
120	400	140	1-266	190	171	361	52.6
			1-267	179	218	397	45.0
			1-274	55	128	183	30.0
		141	1-275	125	171	296	42.3
			1-276	36	43	79	45.5
			Totals	585	731	1316	44.4
200	120	141	1-272	27	120	147	18.4
			1-273	10	57	67	14.9
			Totals	37	177	214	17.3
		141	1-269	31	226	257	12.1
			1-270	30	184	214	14.0
			Totals	61	410	471	12.9
	400	142	1-277	68	358	426	16.0
			1-278	65	327	392	16.6
			1-279	51	308	357	14.3
			1-280	77	361	438	19.3
			Totals	261	1352	1613	16.2
		Controls					
			103	738	293	296	99.0
			58	495	314	326	96.4
				496	490	502	97.6
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			94	720	1061	1077	99.0
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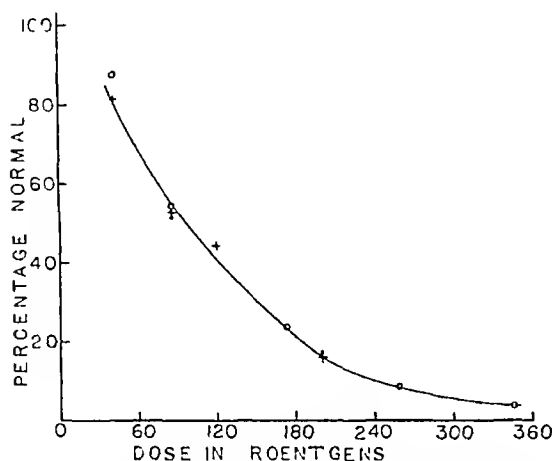


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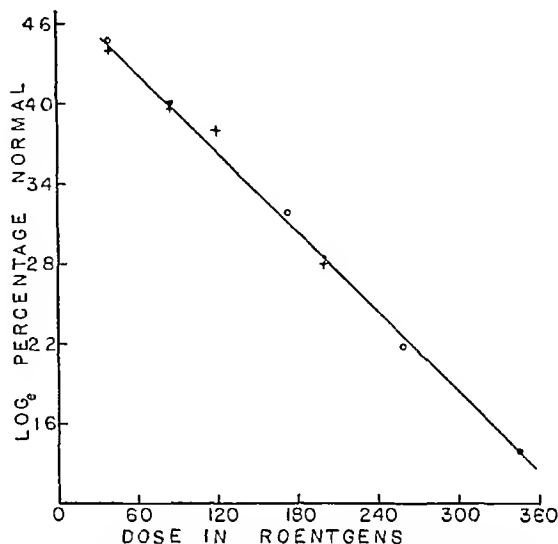


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be done. Furthermore, as demonstrated in a previous publication (28), it is possible by using different types of roots to cover a very wide dosage range. The range from 40 r to 1,000 r has been covered, but might easily be extended on either side.

Of biological phenomena studied by others, some, such as the effect on eggs of *Drosophila* (14, 15, 27) and on eggs of *Ascaris* (26), have been shown to be independent of wave length. The work of Holweck and Lacassagne (19, 20, 21, 24) and of Wyckoff (39) and Glocker (8, 11) has shown that bacteria and yeast are more readily killed by soft than by hard roentgen rays of comparable doses. On the other hand, different experimenters studying apparently the same phenomenon in similar organisms have reported conflicting results with regard to wave length dependence. Skin erythema has been considered independent of wave length by Hess, Holthusen, Determann, Jacobi and Holthusen, Glocker, Hayer and Jungling, and dependent by Glasser and Meyer, Wintz and Rump, Reisner and Neeff, and Hudson. Root elongation of *Vicia faba* has been reported as independent of wave length (Glocker, Hayer and Jungling) and dependent (Bolaffio, Bjorling, Lachmann and Stubbe, Glocker and Reuss). Abnormalities in *Ascaris* eggs were considered independent of wave length by Liechti and Holthusen and Zweifel and dependent though in different manners by Zuppinger and Dognon.

The presence or absence of any wave length dependence has interesting biological implications. If the production of chromosome abnormalities per roentgen is taken to be independent of wave length it follows that changes in the size, ze , the amount of energy per quantum, do not produce any qualitative or quantitative alterations in the response of the radio-sensitive material of the chromosome to the radiation. Glocker (8) has suggested that a biological response which is dependent on wave length might be so obscured by reactions secondary to the

photo chemical action or by biological variability as to appear independent. In the case of chromosomes, however, the variability is quite low and since the response is a simple exponential function, ze , a first order reaction, it seems very unlikely that secondary reactions play any significant rôle in determining the independence observed. It would appear then that the ion pair and not the quantum is the agent effective in producing the chromosome abnormalities observed (28).

SUMMARY

The production of chromosome abnormalities in the cells of the root tips of onion seedlings has been studied as a biological method of measuring roentgen-ray dosage.

The ease of manipulation, low biological variability, and consistency of response make the method a very satisfactory one.

The biological response per roentgen is independent of wave length over the region studied. This is taken to indicate that the ion pair and not the quantum is the agent producing the effects observed.

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BENZEDRINE SULPHATE

ITS EFFECTS ON THE MOTOR FUNCTION OF THE DIGESTIVE TRACT, ON GASTRIC ACIDITY,
AND ON EVACUATION OF THE BILIARY SYSTEM¹

By OPIE NORRIS SMITH, M D, and GEORGE W CHAMBERLIN, M D, Philadelphia

From the Gastro-intestinal Section of the Medical Clinic and the Department of Radiology,
Hospital of the University of Pennsylvania

BENZEDRINE (beta-phenylisopropylamine or benzyl methyl carbinamine), one of the sympathomimetic amines structurally related to ephedrine and epinephrine, has recently been the subject of considerable interest. Because of its volatility and of its constrictive action on the nasal mucosa, it has been proved of value in the treatment of rhinological affections (1). Its stimulating effect on the central nervous system has led to its use, as the sulphate, in the treatment of narcolepsy and of certain depressed and fatigue states (2). Myerson and Ritvo (3), furthermore, have claimed that the sulphate, by its effect on smooth muscle, relaxes spasm of the gastro-intestinal tract and so aids in the roentgen diagnosis and in the treatment of certain digestive disturbances. Myerson, Rinkel, and Dameshek (4) have reported that it also markedly increases the acid secretion of the stomach.

This investigation was undertaken with the view of studying, by roentgen examination and by intubation of the stomach and duodenum, certain effects of benzedrine sulphate, in safe dosage, on the gastro-intestinal tract, both in normal subjects and in hospital patients. Inasmuch as the results in some respects are in agreement, but in others are at variance, with those of previous workers it is believed that they deserve consideration.

ROENTGEN STUDIES

The effect of benzedrine sulphate upon the gastro-intestinal tract was studied

roentgenologically in 28 subjects. These were grouped as follows:

Type of Subject		Number of Subjects
Normal (students)		4
Duodenal ulcer	Acute	6
	Chronic	4
Spastic duodenum"		3
Abnormal colon	Spastic	6
	Smooth	2
Miscellaneous		3

Technic—A barium-and-water mixture consisting of five ounces of barium and five fluid ounces of water was orally administered for the study of the stomach and small intestine and the entire examination was conducted under fluoroscopic control, with interval roentgenograms as indicated. Benzedrine sulphate, usually in a dosage of 20 mg., was given orally in the early part of the study, but later, in order to avoid delay in absorption, by subcutaneous injection. In each of the normal subjects and in some of the patients, a control examination preceded the benzedrine study. All of the patients having duodenal ulcer or duodenal spasm were first studied fluoroscopically without the drug. When, after sufficient time and manipulation, the duodenum could not be filled, 20 mg. of the benzedrine sulphate was given subcutaneously and the fluoroscopic examination continued. In some of the colon cases, the drug was given during the administration of the barium enema, in others it was given after the colon had been filled.

Normal Group—The results in the four subjects of this group were almost identical. Very little effect on gastric peristalsis

¹ Aided by a grant from the Smith, Kline, and French Laboratories



Fig 1-A

Fig 1-A Control study in normal subject



Fig 1-B

Fig 1-B Same subject after administration of benzedrine. Note the gastric residue and delayed small intestinal motility. These films were made at comparable times after the barium was ingested

was noted. The average time for peristalsis to begin after ingestion of the barium was one minute without benzedrine sulphate and slightly less than one minute with it. The depth and speed of the peristaltic contractions were not appreciably altered. Under control conditions, the duodenal cap filled three minutes, on the average, after ingestion of the barium mixture, and slightly later when benzedrine sulphate had been given. The gastric emptying time in the four subjects was prolonged by 38 minutes, one hour 15 minutes, two hours, and four hours 30 minutes, respectively. The drug produced definite changes in the appearance of the small intestine. In every case the motility was delayed, and in three cases peristaltic rushes with some to-and-fro regurgitation were seen. Under control conditions, the barium reached the cecum in two hours 30 minutes on the average, and after benzedrine sulphate in five hours 45 minutes (Fig 1). There was also an increase in the time necessary for the small intestine to become empty. Under control conditions, the average time was seven hours, as compared to approximately ten hours with

the benzedrine sulphate. Changes in the colonic motility were not definite. In one subject there was some delay in the passage of the oral meal through the colon, but this observation was not confirmed in the others.

Duodenal Ulcer Cases—Six cases of acute and four of chronic duodenal ulcer were examined. Relaxation of the duodenal bulb followed the administration of benzedrine sulphate in all of the acute cases, thus rendering definite help in demonstrating the ulcer crater (Fig 2). None of the four chronic cases showed the degree of relaxation seen in the acute group, as would be expected from the nature of the lesion. We believe, however, that benzedrine sulphate is of definite diagnostic aid in certain patients of this type.

Diminution of peristalsis and motor activity of the stomach occurred in three patients within from eight to ten minutes after administration of the drug. When two of these were re-examined one day later under control conditions, peristalsis did not diminish during a 15-minute period of observation. The third patient showed on the following day considerable non-



Fig 2-A Duodenal ulcer before administration of benzedrine



Fig 2-B Same patient after the injection of 20 mgm of benzedrine subcutaneously

opaque residue in an atonic stomach and complained of weakness and nausea. Four minutes after benzedrine sulphate was given, peristalsis became active and the stomach began to empty. He then volunteered the information that the nausea and weakness had lessened. This unexpected observation was made in one other case of an atonic stomach.

In four of the ulcer patients, the gastric emptying time and the small intestinal motility were delayed after the use of benzedrine sulphate. The remaining six were not studied in this respect.

"Spastic Duodenum" Cases—The roentgen diagnosis of "spastic duodenum" is subject to considerable error, since the caliber of the duodenum is determined, in part, by gastric motility and also, in part, by the size of the bolus of barium mixture passing through it. We have employed the term in those instances in which gastric motility was delayed or the bolus passing through the duodenum was small. In none of the three cases observed in the present study was an organic cause for the spasm evident. Careful fluoroscopic study failed at first to visualize the

duodenum, but almost immediately after the parenteral administration of benzedrine sulphate prompt filling of the duodenum occurred. Since the number of cases observed was small, these results are suggestive but not conclusive.

Colon Cases—It is necessary to distinguish clearly between the spastic and the smooth colon. The former may show marked irregularity of the contour of the bowel, the haustrations may be more numerous than usual (Fig 3), or the entire colon may be without definite haustral markings. Under these conditions the injection of the barium mixture frequently causes intense discomfort and, fluoroscopically, a portion of the colon can be seen to contract and expel its contents into a more distal part. In six cases of this spastic type, benzedrine sulphate produced almost immediate relaxation of the colon and relief of pain, so that the barium injection could be continued without further difficulty.

Considered roentgenologically, the smooth, or non-irritable, colon is one having an unusual lack of haustral markings. In the two such cases, we observed no



Fig 3 A Spastic colon before use of benzedrine sulphate



Fig 3 B Same patient 15 minutes after the injection of benzedrine

change in the caliber of the lumen or in the appearance of the haustral markings after the use of benzedrine sulphate

Miscellaneous Cases—This group consisted of one case of pulmonary tuberculosis with small intestinal and colonic hypermotility, one of gastro-intestinal hypermotility apparently due to an acute gastro-intestinal infection of undetermined type, and one of pronounced hypomotility of the small intestine associated with a carcinoma of the head of the pancreas. In each instance delay in gastric and small intestinal motility occurred after benzedrine sulphate. In one patient with a severe diarrhea, barium appeared in the descending colon 30 minutes after its ingestion. He was then given 10 mg of benzedrine sulphate three times daily for several days and subsequently re-examined, at which time the head of the barium column did not reach the descending colon until 4 hours and 20 minutes after ingestion of the opaque meal.

GASTRIC SECRETION

Six healthy medical students and seven ambulant patients hospitalized for various medical conditions were subjected to du-

plicate gastric analyses with identical technique except for the administration of benzedrine sulphate before one of the tests. 30 mg were ingested 45 minutes before the test meal in three instances, and 20 mg were dissolved in the gruel given to each of the remaining ten subjects.

Technic—The analyses were performed in the early morning, the subjects having had no food since supper and no liquids since bedtime. A small-bore rubber tube with metal bucket was passed, the gastric contents aspirated, and 300 c c of oatmeal gruel swallowed. Beginning a half-hour after the test meal, 10 c c samples of the gastric contents were withdrawn every 15 minutes until 90 minutes had elapsed, at which time the stomach was entirely emptied. One c c samples of each specimen were diluted with distilled water, and promptly titrated with N/50 sodium hydroxide, using Topfer's reagent and phenolphthalein as indicators. The acidity values were recorded in conventional units. Histamine was not given.

Taken as a single group, the 13 subjects showed very slight increase in gastric acidity after benzedrine sulphate. In the hospital patients, the acidity curves showed

insignificant change after the drug. In healthy subjects, there was moderate increase in acidity after the administration of histamine, which was not altered either by benzedrine or by benzedrine sulphate. In one hospital patient with complete achlor-

THE EFFECT OF BENZEDRINE UPON GASTRIC ACIDITY

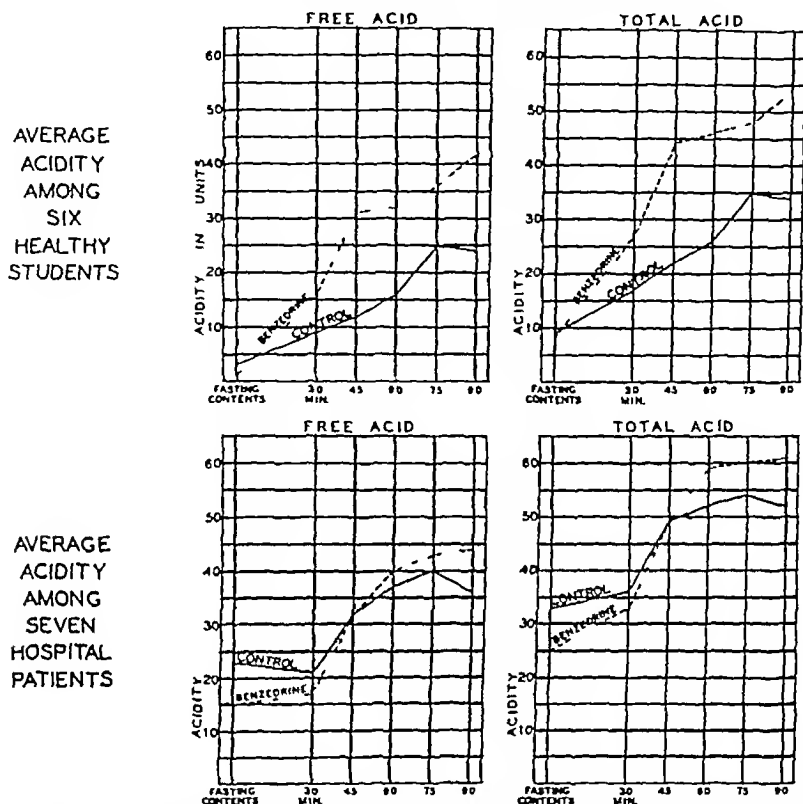


Chart I Twenty milligrams of benzedrine sulphate orally produced a mild elevation of gastric acidity in healthy medical students but no significant change in the acidity of convalescent hospital patients. The volume of the gastric residue was not affected.

of benzedrine sulphate, averaging 16 units after the 30-minute specimen. When the benzedrine sulphate was dissolved in the gruel, variations were rarely appreciable before the 45-minute specimen. The curves for total acid reflected the same general changes as did those for the free hydrochloric acid.

When the drug was administered 45 minutes before the test meal, no constant increase in the acidity of the fasting gastric contents was observed. The average volume of gastric residue at the end of the analysis was virtually identical under control conditions and with benzedrine sulphate.

One normal subject had complete achlor-

hydria after the gruel meal, a maximum of six units of acid was found after the administration of benzedrine. The effect of histamine in this individual was not determined.

BILIARY DRAINAGE

In six fasting patients, 20 mg of benzedrine sulphate dissolved in 10 c c of warm water was introduced into the duodenum by tube. During a 30-minute observation period, no drainage from the biliary system was apparent in any case. At the end of this period the introduction of olive oil into the duodenum effected prompt evacuation of the biliary system in each patient. This suggests that 20 mg of the drug

neither stimulates the musculature of the gall bladder nor inhibits contraction of the sphincter of Oddi, partially confirming the results of Schube *et al* (6), based upon roentgen observations

TOXICITY AND UNTOWARD EFFECTS

One of our patients exhibited an alarming reaction several hours after the ingestion of 30 mg of the drug. This incident occurred early in the course of our study, with the result that subsequently we did not exceed a dose of 20 mg.

Case Report—A white woman, 36 years of age, who complained of weakness and weight loss, was found to have a moderate secondary anemia, apparently due to bleeding hemorrhoids and menorrhagia. Eight days after admission she was given 10 mg of benzedrine sulphate without ill effect. Early the next morning, preceding a gastric analysis, 30 mg of the same drug was administered orally. An hour later her blood pressure had risen from 114/70 to 134/76, while her pulse had dropped from 100 to 76. After another 30 minutes she began to complain of a "hot feeling" and in the late afternoon she lost consciousness and had irregular spasmodic twitchings of the arms for a brief period, subsequently, with return of consciousness, she complained of numbness of the arms and hands and had impairment of pain sense in those parts. Doryl (carbinoylcholine), administered subcutaneously, brought about complete relief within five minutes and her blood pressure promptly dropped to 105/65.

Although the belated appearance of this reaction raises some doubt as to the part played by benzedrine sulphate, nevertheless the character of the symptoms, their prompt alleviation by a choline derivative, and their absence at other times suggest that it was responsible.

Severe headache may follow the ingestion of only 5 mg of the drug. The blood pressure may rise, although usually little change has been observed with oral doses of less than 30 mg. The central nervous system stimulation effected by benzedrine

sulphate in psychiatric patients has been described (5) as resulting in euphoria and elation. Among the normal subjects of our study, however, we found that the not infrequent headache, mental excitement, and sense of nervous tension produced by it did not constitute a "sense of well-being." All reports agree that insomnia usually precludes the use of the drug for from six to eight hours before retiring.

COMMENT

A study of the actions of a drug on the motor functions of the human gastrointestinal tract is complicated by the fact that it is impossible to eliminate with certainty the various extraneous factors known to influence tone, peristaltic activity, and motility. In this study, therefore, we have regarded as significant only those effects which were so striking as to be unmistakable. Our observations indicate that benzedrine sulphate in doses of 20 mg has no effect on peristalsis in the stomach of normal tonus. In all of our cases in which we had control studies, the gastric emptying time was prolonged. This observation differs from that of Myerson and Ritvo (3), who state that "the stomach actually empties more rapidly than normal under the influence of the drug." In two of our patients having atonic stomachs peristalsis became active after the use of benzedrine sulphate. This observation requires corroboration.

In the small intestine delay in the motility of the barium mixture occurred after the administration of the drug. Other variations from normal were not striking, and in only an occasional case did the observations indicate increased caliber. Gas in the small intestine was occasionally observed in normals. Fluoroscopically, a moderate amount of to-and-fro churning and an occasional peristaltic rush in the proximal small intestine in three of our normal subjects was observed. Such disturbances are a disadvantage to the radiologist who is interested in a comprehensive study of the motor functions of the gastro-intestinal tract. The routine use of

insignificant change after the drug. In healthy subjects, there was moderate increase in acidity after the administration of histamine or by benzedrine sulphate. In one hospital patient with complete achlor-

THE EFFECT OF BENZEDRINE UPON GASTRIC ACIDITY

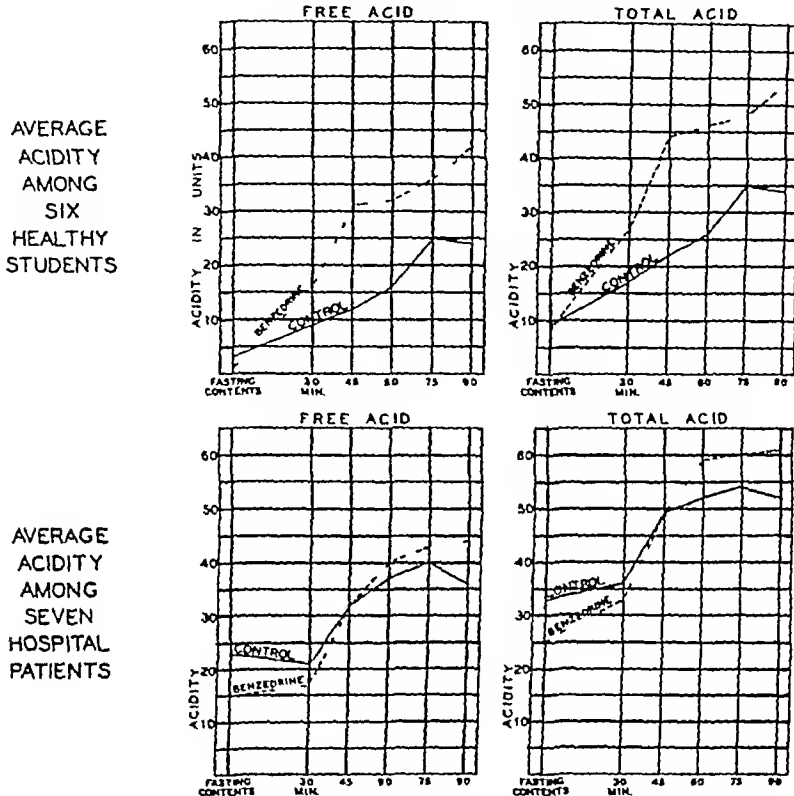


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THE EFFECT OF LARD OIL, SESAME OIL, ACACIA, RETENE, AND 1 2 5 6 DIBENZANTHRACENE
ON CERTAIN ORGANS AND A TRANSPLANTABLE RAT SARCOMA IN
ANIMALS OF PURE BREED

By JOSEPH A POLLIA, M D , *Los Angeles, Calif*

From the Frank H Boyer Foundation

It has been found by Haddow (1), Haddow and Robinson (2), and Scott (3) that injections of certain carcinogenic hydrocarbons inhibit the growth of Jensen or Walker rat tumors, or of young rats without producing ill health or "undoubtedly significant changes" in various organs. However, it is well known that sickness in animals invariably inhibits tumor development.

The importance of Haddow's (1) observation and the possible application to cancer treatment led to the experiments reported in this paper.

The effect of the compounds was studied upon a tumor, B, No 2, propagated in this laboratory from a spontaneous uterine growth, probably a sarcoma, in an old female, and transplanted into pure bred, young adult rats (Fig 1). It yields 100 per cent takes and, to date, without a single instance of spontaneous regression, but when the tumor is inoculated into another breed the yield immediately drops to about 30 per cent.

Transplantation of the Tumor—All tumors are transplanted in the form of a suspension of cells produced by grinding the tumor in a Fischer embryo juice press that contains 20 and 80 mesh metal cloth strainers, respectively, and then diluting it with Tyrode's solution to the required concentrations.

Compounds Tested—The materials tested were (1) Light's London, England, 1 2 5 6 dibenzanthracene, (2) Eastman Kodak Company's Retene, $C_{18}H_{18}$, which contains the phenanthrene nucleus, but is not related to the sterols, and as yet without indications of carcinogenic effect, (3) lard oil, (4) household and distilled sesame oil, (5) acacia, and (6) Belgian Chemical Company's 3 4 benzpyrene which had to be

abandoned during the preliminary experiments because of great toxicity and 100 per cent mortality.

The two hydrocarbons were given as colloidal suspensions and sesame oil solutions. It was found that lard oil took up four times as much retene as sesame oil, but the dibenzanthracene dissolved by both oils was the same. The lard oil, prepared according to Burrows *et al* (4), when injected intraperitoneally produced so much organized material that it was distilled at 35° C, but since this did not remedy the difficulty, sesame oil was finally selected for all the reported experiments.

The Sesame Oils—Two brands of sesame oil were employed: (1) a pure distilled brand, furnished by the Eastman Kodak Company, through the courtesy of Dr Mees, and (2) the household variety.

Sterilization of Materials—The solutions in lard and sesame oil were sterilized in a household gas hot air oven at 150° C. for one hour. Colloidal solutions prepared according to Berenblum (5) were autoclaved for 20 minutes at a steam pressure of 15 pounds. These methods caused no perceptible break-down of the hydrocarbons or of the oils which could be detected by any change in color or odor. A total of 250 animals was used, 96 in preliminary experiments, to standardize the technic, and the 154 animals in the work reported here. Since both the preliminary and final experiments showed that retene and 1 2 5 6 dibenzanthracene had definitely inhibited tumor B, No 2, the first reported experiment was to determine if the Arndt-Schulz law, that weak stimuli increase while strong ones inhibit physiological activity, could be elicited on B, No 2, with minute doses of carcinogenic compounds.

Experiment 1—The effect of dilute col-

benzedrine sulphate as a diagnostic aid in gastro-intestinal roentgenology, therefore, is unnecessary and may be confusing. We believe, however, that the drug may be of value in the roentgen examination of certain cases of organic or functional spasm of the duodenum in which the usual methods of examination are inadequate. We have found it useful in relaxing the spastic colon during a barium enema, and it has not only enabled us to fill the colon easily and completely, but also has relieved the patient of much discomfort.

Gastric analysis showed that there was only a slight increase in acidity following the administration of 20 mg of benzedrine sulphate. When present, the increase appeared to be somewhat greater in the normal individuals than in the hospital cases. Our failure to demonstrate an increase in the acidity of the gastric contents, as reported by Myerson and his co-workers (4), is perhaps due in part to the type of subject used. Our reluctance to equal their larger dosage, however, is doubtless a more important factor in explaining the discrepancy.

Previous workers (6) have found that under certain conditions the gall bladder fails to empty after the administration of benzedrine sulphate. Our results seem to indicate, however, that although it produces no evacuation, it does not interfere subsequently with the usual emptying effect of olive oil.

CONCLUSIONS

On the basis of a study of the gastro-intestinal tract of 28 human subjects by the roentgen ray, of 15 subjects by gastric analysis, and of 6 by duodenal drainage

after the administration of from 20 to 30 mg doses of benzedrine sulphate, the following conclusions as to the action of the drug seem justified:

1 It does not affect peristalsis in the normal stomach, but in three patients with duodenal ulcer it had an inhibitory effect, and in two with gastric atony it had a stimulating effect.

2 It delays the emptying time of the stomach.

3 It delays small intestinal motility.

4 By its relaxing effect on smooth muscle it often is an aid in the roentgen diagnosis of acute and chronic ulcer of the duodenum, of duodenal spasm, and of the spastic colon.

5 It increases gastric acidity to a slight extent in normals, but to an insignificant degree in patients such as we have studied.

6 As indicated by duodenal drainage, it does not stimulate evacuation of the biliary system.

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There was practically no variation in the average tumor weight between the untreated and sesame oil animals. The greatest amount of inhibition was found, as expected, with dibenzanthracene, however, the effect of retene is remarkable since it is unrelated to the carcinogenic compounds except that it is a phenanthrene derivative. The considerable damage to various organs is summarized in Table IV.

Experiment 4—The effect of household sesame oil solutions. Series of April 29, 1937. Twenty animals.

TABLE V—AVERAGE WEIGHTS

Treatment	Animal	Tumor	Per centage of Tumor Variation
Untreated	143.6 gm	31.4 gm	100.0
5 c.c. oil	130.0 gm	29.7 gm	94.6
600 mgm retene	105.5 gm	18.8 gm	59.9
50 mgm 1,2,5,6 dibenzanthracene	126.6 gm	8.4 gm	27.1

Experiment 4 is a duplicate of Experiment 3. Four groups of five rats each were inoculated with B, No. 2, tumor and given the same treatment. Comparison of the weights of the tumors in the controls and treated animals shows very little variation in the two experiments.

TABLE VI—AUTOPSY FINDINGS IN EXPERIMENT 4

Treatment	Liver	Kidneys	Spleen	Peritoneum
Untreated	Metastasis (1)	Normal	Normal	Normal
Sesame oil	Swollen (5)	Normal	Normal	Acetone odor (all), some milky fluid (all), free oil (1)
Retene	Deposits (all), swollen (all)	Normal	Deposits (all)	Material organized in nodules (all), free oil (all), fluid (all), ascites (all)
1,2,5,6	Deposits (3)	Inflammation (?) (1)	Deposits (3)	Free oil (3), ascites (3), fibrous adhesions (1)

The lungs were normal in all of this series.

Is the inhibition just discussed due to a specific effect on the tumor cell or to an effect on the whole animal? There is some evidence in favor of the latter possibility in the observation of Scott, who has shown that rats treated with 1,2,5,6 dibenzan-

thracene had an average weight decrease of 45.8 per cent as compared with the 93.4 per cent of those receiving sesame oil and

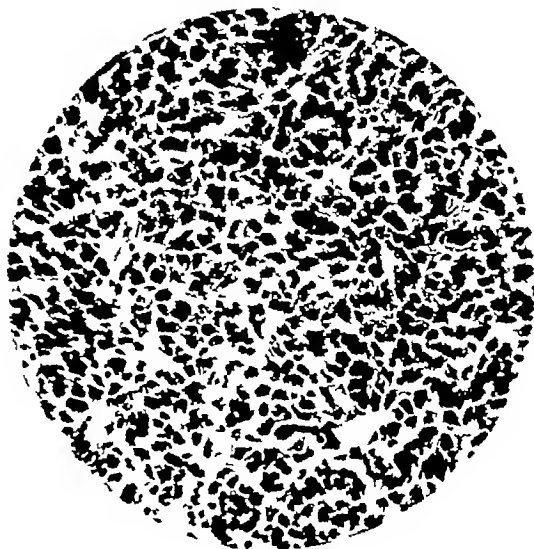


Fig. 1. Rat sarcoma B No. 2.

96.5 per cent of those which had gotten 10 mgm of the non-carcinogenic pyrene. If, on the contrary, the inhibitions were due to a specific effect, tumors developing from small inocula should be more susceptible than those from larger ones. Therefore the following experiment was performed. Sixteen rats weighing about 125 to 150 grams were inoculated with B, No. 2, suspension

in quantities 0.01 c.c. to 0.0001 c.c. in the right axilla and hypochondrium, and 0.001 and 0.00001 c.c. in the left axilla and hypochondrium. The following day eight were given 5 c.c. of colloidal solution of 1,2,5,6 dibenzanthracene intraperitoneally which

coloidal solutions of retene and 1 2 5 6 dibenzanthracene Series of April 14, 1937 Twenty-four animals were injected intraperitoneally five times with 5 c c of solution Table I gives the final results

TABLE I—AVERAGE WEIGHTS

Treatment	Tumor	Percentage of Variation
Untreated	42.4 gm	100.0
5 times 5 c c 1 per cent acacia	33.6 gm	79.2
5 times 5 c c of retene 1 mg	35.5 gm	83.2
5 times 5 c c of dibenz 2.25 mg	29.9 gm	70.3

Therefore, it is suggested that small doses of these hydrocarbons and acacia do not accelerate but inhibit the growth of B, No 2

Experiment 2—Since small doses of 1 2 5 6 dibenzanthracene and retene inhibit instead of accelerate the growth, in the following experiment concentrated colloidal solutions were used The effect of concentrated colloidal solutions of hydrocarbons Series of April 21, 1937 Thirty-three animals were treated with three intraperitoneal injections of 5 c c each

This experiment shows an unexplained increased growth in the animals which received acacia and retene, but a decrease by 22.9 per cent in those given 1 2 5 6 dibenzanthracene Autopsy showed no organic changes in the untreated controls or the acacia animals, but there was present an increase in the connective tissue around the liver, ascites and deposits of retene in one of the eight rats, while deposits of 1 2 5 6

TABLE II—AVERAGE WEIGHTS

Treatment	Animal	Tumor	Percentage of Tumor Variation
Untreated (8 rats)	114.0 gm	16.2 gm	100.0
15 c c 6 per cent acacia (8 rats)	130.0 gm	19.4 gm	119.7
3.98 mg retene in 15 c c of sol (8 rats)	123.0 gm	18.4 gm	113.5
4.0 mg 1 2 5 6 in 15 c c of sol (9 rats)	132.0 gm	12.5 gm	77.1

dibenzanthracene in the peritoneal cavity and ascites were present in four rats The kidneys and lungs were the same as those of the untreated controls

The next experiment deals with household sesame oil solutions, in which the rats were injected intraperitoneally with one dose of 5 c c

Experiment 3—The effect of household sesame oil solutions Series of April 22, 1937 Twenty animals

TABLE III—AVERAGE WEIGHTS

Treatment	Animal	Tumor	Percentage of Tumor Variation
Untreated	119.6 gm	30.7 gm	100.0
5 c c household sesame oil	111.0 gm	30.0 gm	97.7
600 mgm of retene 5 c c S O	105.0 gm	14.6 gm	47.5
50 mgm 1 2 5 6 dibenz in 5 c c. S O	123.5 gm	10.7 gm	32.2

TABLE IV—AUTOPSY FINDINGS

Organs	Untreated	Sesame Oil	Retene	1 2 5 6 Dibenzanthracene
Lungs	Normal	Metastasis (1)	Normal	Normal
Liver	Normal	Oil organized under surface (4)	Material organized (4) metastasis (1)	Material organized (5) swelling (1)
Kidney	Normal	Normal	Normal	Normal
Spleen	Normal	Normal	Normal	Normal
Peritoneum	Normal	Oil organized (4)	Material organized in nodules (4) Free oil (3) Metastasis (1)	Free oil (3) ascites

Number of rats in each group showing pathologic change is indicated by the numeral.

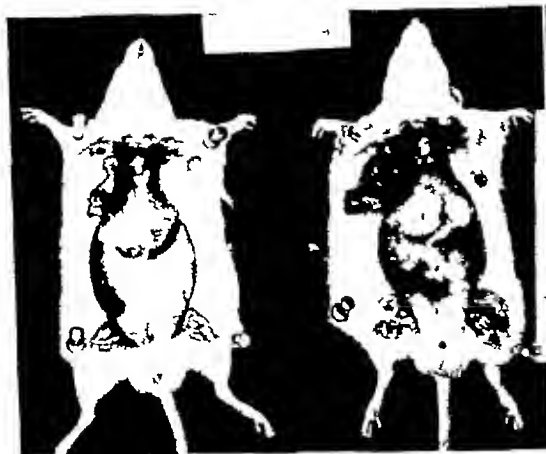


Fig 2

Fig 2 Distention of the abdominal cavity by fluid from the injection of sesame oil solution of 1 2 5 6 dibenzanthracene in Experiment 6

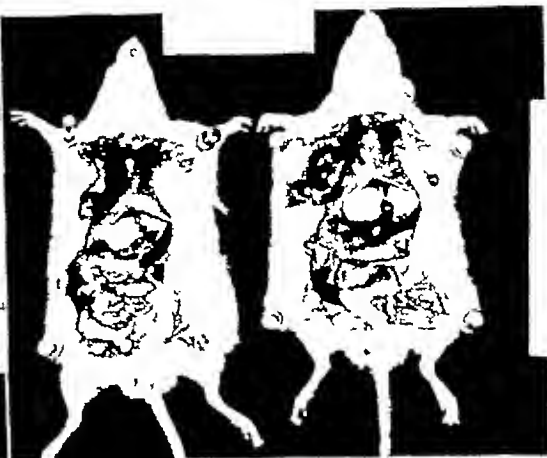


Fig 3

Fig 3 Deposits of 1 2 5 6 dibenzanthracene in the abdominal cavity of the animals shown in Figure 2

peritoneally Fourteen days later all 16 were sacrificed, examined, and the above mentioned organs removed and fixed in 10 per cent formaldehyde Frozen sections were made for microscopic study, and stained with hematoxylin-eosin As will be seen in Table IX, the same effects on tumor size were found as in the preceding experiments

TABLE IX —AVERAGE WEIGHTS

Treatment	Animal	Tumor	Per centage of Tumor Variation
Untreated	138.9 gm	14.7 gm	100.0
5 c c sesame	117.0 gm	7.5 gm	51.0
600 mg retene	116.0 gm	4.5 gm	30.6
50 mg dibenz	124.0 gm	2.6 gm	17.6

Except that the sesame oil produced a marked inhibition—a difference of 49.0 per cent which has not been observed in Experiments 3 and 4—and the figures for retene being only slightly less than for sesame oil, the expected variations were noted, with dibenzanthracene again showing the greatest inhibition

The blood counts taken immediately before the experiment was terminated, when compared with the count obtained before treatment began showed a slight de-

crease in hemoglobin for the untreated animals, while sesame oil, retene, and 1 2 5 6 dibenzanthracene seemed to keep it within the starting limits Since anemia is one of the consistent effects of tumor B, No 2, it can be said that those materials had a slight "salutatory" effect No comment can be made on the red cells as the variation is not sufficient A very interesting change took place in the leukocyte count, which increased 28.3 per cent for the group of untreated, but showed a decrease in the sesame oil, retene, and but slightly or negligibly in dibenzanthracene The percentage of variation in the polymorphonuclear group was the most striking of the blood effects, for here the untreated controls gave 183.1 per cent increase, sesame 36.6 per cent, dibenzanthracene 75.4 per cent, but an enormous increase for retene, which yielded 451.6 per cent The autopsy findings were similar to those found in the previous experiments with sesame oil solutions and are summarized in Table X

Microscopical sections of liver, peritoneum, pancreas, peripancreatic content Tissue, kidneys, lungs, spleen show in each animal the presence of a variety of inflammatory changes correlated in detail in Table XI

Distilled sesame oil Series of June 4, 1937 Sixteen animals (Table X)

contained 2.5 mgm to insure the maximum absorption. Fourteen days later they were sacrificed. Table VII shows in a most striking manner that the dibenzanthracene-treated animals had tumors which were 45.2 per cent less in weight than the controls, but the number of takes with 0.00001 cc were three for the untreated and also three for the treated. This suggests that the inhibition is a general and not a specific effect. These multiple inoculations of varying sizes were done several times with the same results.

Again one notes pathologic effects in the abdomen, deposits of the hydrocarbon on the abdominal organs, death of embryos, fluid in the peritoneal cavity, adhesions and swelling of the liver (Table VIII).

Experiment 5—The effect of concentrated colloidal solutions of 1.256 dibenzanthracene on the growths from various volumes of tumor suspensions. Series of May 5, 1937. Sixteen animals. Multiple tumors from 0.01 cc, 0.001 cc, 0.0001 cc, 0.00001 cc of suspension.

Up to this time there had been considerable doubt, in view of Haddow's careful work, that the changes observed in the organs played any part in the inhibition of tumor growth. However, it was gradually becoming inescapable that there were far more pathologic alterations in the author's animals than would be expected since it is stated that no evidence was found to suggest that the inhibition obtained in Haddow's experiments was due to a general toxic effect. Therefore, Experiment 6 was planned so that the blood, thymus, lungs, heart, liver, spleen, kidneys, and genitalia could be studied carefully, grossly as well as microscopically, to determine whether the extent of these pathologic conditions was sufficient to be responsible for part of the lack of growth in the tumors of treated animals. In the dibenzanthracene rats, the thymus had been difficult to find, which seemed unusual since in the controls the gland was of a normal size. In the same manner already stated, four groups of four rats each were inoculated with 0.01 cc,

TABLE VII—AVERAGE TUMOR WEIGHTS IN GRAMS

Treatment	Animal	0.01 cc.	0.001 cc	0.0001 cc	0.00001 cc	Percentage Variation of Total Tumor Tissue
Untreated	157	7.3	1.6	0.4	Three takes too small to weigh	100.0
2.5 mg 1.256 dibenzanthracene	152	3.4	0.7	0.1	Three takes too small to weigh	45.2

TABLE VIII—AUTOPSY FINDINGS. NUMBER OF RATS IN EACH GROUP SHOWING PATHOLOGIC CHANGE

Treatment	Lungs	Liver	Kidney	Peritoneum	Spleen	Miscellaneous
Untreated	Negative	Negative	Negative	Negative	Negative	Normal embryos (1)
1.256 dibenzanthracene	Negative	Deposits (5) swollen (1)	Negative	Fluid (all) adhesions (1)	Deposits (5)	Abnormal embryos dead (1) pallor (2)

Experiment 6—The effect of distilled sesame oil solutions of retene and 1.256 dibenzanthracene on Tumor B, No. 2, series of June 4, 1937. Sixteen animals. Multiple tumors from 0.01 cc and 0.001 cc of tumor tissue.

0.001 cc, 0.0001 cc, and 0.00001 cc of tumor suspension B, No. 2. The following day one group was set aside as untreated controls and the remaining three were given 5 cc of sesame oil, and retene and dibenzanthracene in oil solution, intra-

benzanthracene From the degree of pathologic change in the liver and the relative freedom from trouble in the kidneys and spleen, it would seem that liver dam-

metastases in one animal of the retene and acacia group were negative for all organs examined, as indicated in Table XIII

Concentrated colloidal solutions, 2 c c



Fig 4

Fig 4 Intense cellular reaction of the peritoneal coat in the animals injected with sterilized distilled sesame oil (450 X hematoxylin-eosin)

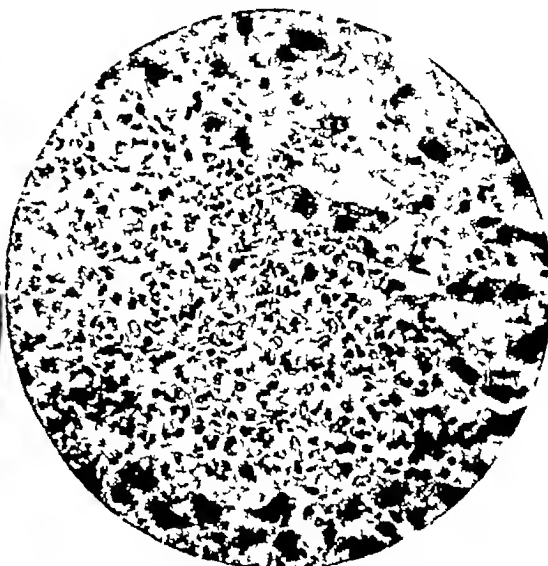


Fig 5

Fig 5 Extensive focal necrosis of the liver from distilled sesame oil solutions of 1 2 5 6 dibenzanthracene (450 X hematoxylin-eosin)

age may be one of the factors in the inhibition of tumor growth

intracardiac injection Series of June 7, 1937 Sixteen animals (Table XIII)

The autopsy findings except for lung

Except for the accidental occurrence of

TABLE XII —AVERAGE WEIGHTS

Treatment	Animal	Spleen	Tumor	Percentage of Tumor Variation
Untreated	147 4 gm	0 7 gm	12 0 gm	100 0
2 c c of 6 per cent acacia	151 9 gm	0 8 gm	11 2 gm	93 3
2 c c retene sol 0 88 mg	126 0 gm	0 7 gm	8 8 gm	73 2
2 c c 1 2 5 6 dibenzanthracene 1 0 mg	151 0 gm	0 6 gm	8 4 gm	70 5

TABLE XIII —TABLE OF AUTOPSY FINDINGS NUMBER OF RATS IN EACH GROUP SHOWING PATHOLOGIC CHANGE

Treatment	Lungs	Liver	Kidneys	Peritoneum	Spleen
Untreated	Negative	Negative	Negative	Negative	Negative
Acacia	Metastasis (1)	Negative	Negative	Negative	Negative
Retene	Metastasis (1)	Negative	Negative	Negative	Negative
1 2 5 6 dibenzanthracene	Negative	Negative	Negative	Negative	Negative

TABLE X—TABLE OF AUTOPSY FINDINGS NUMBER OF RATS IN EACH GROUP SHOWING PATHOLOGIC CHANGE

Treatment	Lungs	Liver	Kidney	Peritoneum	Spleen	Thymus
Untreated	Negative	Negative	Negative	Negative	Negative	Negative
Sesame oil	Negative	Swollen (4) deposits (4)	Negative	Free oily solution (4), acetone odor (4), some organization of oil (4)	Deposits (4)	Negative
Retene	Negative	Swollen (3)	Negative	Material organized in nodules (3) only fluid, 0.5 to 1 c.c. (4)	Negative	Atrophy (4)
1 2 5 6	Negative	Deposits (4) (Fig 3) swollen (3)	Negative	Ascites (4) (Fig 2) sero sanguinous, only fluid 6.5 to 13 c.c. (4)	Deposits (4)	Atrophy (4)

TABLE XI—TABLE OF MICROSCOPICAL FINDINGS

Organs	Liver	Peritoneum	Pancreas	Peri pancreatic Con Tissue	Kidneys	Lungs	Spleen
Untreated	Negative	Negative	Negative	Negative	Negative	Slight pneumonic changes	Negative
5 c.c. sesame oil	Hyperemia	Marked cell infiltration (Fig 4)	Necrosis	Cellular infiltration	Slight change (?)	Definite extravasation of blood	Change in hematopoietic tissue
600 mg retene	Mod no areas focal necrosis	Thickening (?) edema	Necrosis	Marked cellular infiltration	Slight change (?)	Definite extravasation of blood	Change in hematopoietic tissue
50 mg 1 2 5 6 dibenzanthracene	Extensive focal necrosis (Fig 5)	Atrophy with cellular infiltration	Necrosis (Fig 5)	Marked cellular infiltration	Slight change (?)	Definite extravasation of blood	Change in hematopoietic tissue

Heart muscle and the tumor B No 2, apparently were in no way affected by the treatment given the animals

Distilled sesame oil solutions Series of June 7, 1937 Sixteen animals (Table XI)

Experiment 7—The effect of concentrated colloidal solutions, 2 c.c. intracardiac injection Series of June 7, 1937 Sixteen animals

The visible deposits of hydrocarbons, described above, indicated that dibenzanthracene and retene in sesame oil are poorly absorbed, since such a large amount is precipitated or organized. Concentrated colloidal solutions seem to suffer the same fate, as considerable precipitation also occurs, if the amount injected is taken into consideration. Therefore, the only way in which complete entrance of the dose in the body can be assured seems to be by injection of the colloidal solutions of the compounds into the blood stream.

Accordingly four groups of four rats each, weighing about 100 grams, were inoculated in the manner described, with 0.01 c.c., 0.001 c.c., 0.0001 c.c., and 0.00001 c.c. of suspension of tumor B, No 2, and the next day three groups received intracardiac injections under ether of 2 c.c. of acacia, 2 c.c. of colloidal retene solution containing 0.88 mg., and 2 c.c. of colloidal solution of 1 2 5 6 dibenzanthracene containing 10 mg. The untreated controls were also anesthetized and punctured, but did not receive any injection.

This Table XII shows the same tendency to inhibition in the growth of the tumor as has already been noted in the intraperitoneal injections, but to a much less degree, which may be accounted for by the small dose of the retene and 1 2 5 6 di-

ar to those observed in the previous experiments in which sesame oil and its solutions of retene and 1 2 5 6 dibenzan-

bright yellow oil to appear in aspirated quantities of 4 0-13 5 c c However, one very interesting observation concerned the

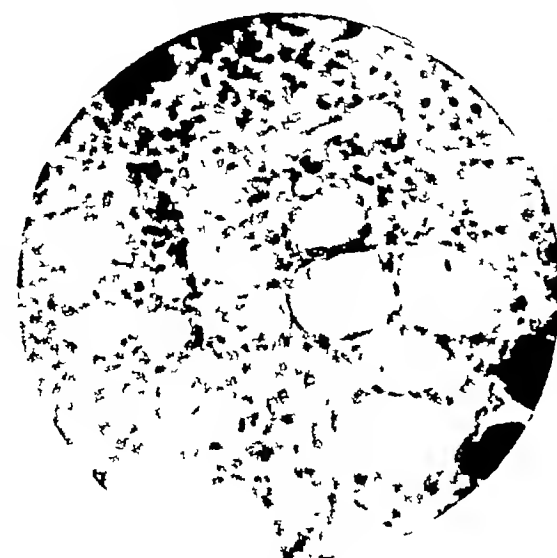


Fig 6

Fig 6 Marked degenerative changes in the pancreas of animals treated with retene in sesame (450 X hematoxylin-eosin)



Fig 7

Fig 7 Focal necrosis of the liver in animals receiving intracardiac injections of colloidal suspension of 1 2 5 6 dibenzanthracene in 6 per cent acacia (450 X hematoxylin-eosin)

thracene were used, made in accordance with the oral instructions Therefore, the pronounced general toxic effects in the author's animals could not be due to the difference in preparation, concentration, and sterilization of the materials The volume used in the published technic was twice that employed in the previous experiments herein described The injection of this amount in this experiment caused proportionately greater lesions, deposits of hydrocarbon, sero-sanguinous fluid, and

unheated sterile sesame oil The entire amount had been converted into a milky emulsion the consistency of gruel, one probable stage in the changes undergone by this oil in the peritoneal cavity

The failure of very much of the dibenzanthracene solution to be absorbed in every experiment was not altogether unexpected because an injection given a rat two months before produced yellow-orange colored formations under the diaphragm, between the liver lobes, around the spleen,

TABLE XIV —AUTOPSY FINDINGS

Treatment	Thymus	Lungs	Liver	Peritoneum	Spleen	Kidneys
Sesame oil (2 X 5 c c)	Normal	Normal	Swollen (all) Plaque of organized oil between dome and diaphragm	4 + organization of oil (all) Inflammation (2) Acetone odor (1) Extravasation of blood (1)	Normal	Normal
0 5 per cent 1 2 5 6 dibenzanthracene (2 X 5 c c)	Atrophy (all)	Normal	Swollen (2) Large plaques of organized material (all)	Sero-sanguinous only fluid (all) Inflammation (1) Nodules of organized material (all)	All or part coated with 1 2 5 6 dibenzanthracene	Normal
1 0 per cent 1 2 5 6 dibenzanthracene (2 X 5 c c)	Atrophy (all)	Sero-sanguinous fluid in pleura (1)	Swollen (all) Large plaques of organized material (all)	Sero-sanguinous only fluid (all) Inflammation (all) Nodules (all)	All or part coated with 1 2 5 6 dibenzanthracene	Deposits (2)

lung metastases in the acacia- and retene-injected animals, there were no gross abnormalities observed in these post-mortem examinations

COMMENTS ON PHOTOMICROGRAPHS

Microscopic sections were made of the liver, kidney, and tumor in Experiment 7. The liver suffered damage in both the retene and dibenzanthracene animals. Although they were not of the same degree as those seen in sesame oil solutions, still they were consistent with the pathologic effects of the same hydrocarbons in the sesame oil solutions

SUPPLEMENT

Haddow and Robinson (2), Haddow (1), Scott and Scott (6) described a method of preparing their sesame oil solutions different from that used by the author. They heat their solutions to 100° C, and in all but one exception use 0.5 per cent of 1,2,5,6-dibenzanthracene in contrast to heating at 150° C for one hour of a 1 per cent solution. Scott notes that the systemic absorption of 1,2,5,6-dibenzanthracene is probably less at 1 per cent because of precipitation, and used it only in one experiment. In addition, the authors cited gave two injections, using about twice as much, and also stated that the sterilization process serves to dissolve the dibenzanthracene, but did not say how long the heat is applied.

All of the dibenzanthracene solutions used in the preceding experiments were 1 per cent, and heated at 150° C, for one hour, but this treatment was not sufficient to dissolve the material entirely and on cooling to body temperature, a considerable portion crystallized out. It is possible that if these oils were heated too long in the presence of air, and oxidation had taken place, with the production of irritating substances such as aldehydes, that would explain the varying degrees of peritoneal reaction found above, although it would not account for the definite liver changes seen when the small doses of

retene, and 1,2,5,6-dibenzanthracene were injected into the rat's blood stream. Therefore in Experiment 8, the materials were prepared in accordance to the published technic.

Solutions of 0.5 per cent and 1.0 per cent of Eastman Kodak Company's 1,2,5,6-dibenzanthracene, M.P. 258–260° C, were prepared, corked with cotton plugs, placed in the hot air oven and heated to 100° C. After two hours, aided by frequent shaking and mashing with a sterile glass rod, the material in the 0.5 per cent showed complete solution except for one tiny crystal, but in the 1.0 per cent it did not completely dissolve even after two and one-half hours. Then it was taken out, but when the two concentrations were allowed to cool to 37° C, a considerable number of crystals reappeared, which caused both fluids to become opalescent.

The following day three Wistar rats, average weight 135 grams, three of mixed breed, average weight 100 grams, and three pure strain, average weight 90 grams, were separated into three groups, consisting of one Wistar, one mixed, and one pure strain. The first group received two doses of 5 c.c. each of 0.5 per cent solution of 1,2,5,6-dibenzanthracene on two consecutive days, and the second group was given two doses of 5 c.c. each, also on consecutive days of the 1.0 per cent solution heated to 100° C for two and one-half hours. The third group was used for the sesame oil treatment. In order to eliminate the possible presence of injurious products from heating, 30 c.c. of distilled sesame oil was withdrawn from the lower third of the container with sterile technic in such a way as to insure at least the absence of mass aerobic contamination. The animals were injected intraperitoneally with two doses of 5 c.c. each of this unheated oil on two consecutive days. Twenty-one days later, all nine animals were sacrificed. The autopsy findings described in Table XIV show that the lesions produced by unheated sterile sesame oil and by a solution of dibenzanthracene, made in accordance with the published technic, were simi-

certain amount of debilitating action" which was indicated in the higher correlation values for the various organs of the control groups except in the case of the brain and spleen

Beltrami (9) noted that painting mice with 1, 2 benzpyrene, benzol, or anthracene caused changes in the liver and spleen of these animals suggestive of a general toxic reaction, since the splenic pulp and the blood vessel walls of the spleen and other organs were the site of amyloid degeneration, while the liver was the seat of foci of immature blood corpuscles in the portal spaces and capillaries of the lobules

Pybus and Miller (10) report that intraperitoneal injections of solutions of 1 2 5 6 dibenzanthracene in mice caused a high mortality, with findings of peritoneal adhesions and degenerations of the liver and kidneys

SUMMARY

A number of white rats of pure breed, bearing sarcomas (about 20 cm or more in diameter), were given intraperitoneal injections of 1 2 5 6 dibenzanthracene or retene dissolved in sesame oil or in the form of a colloidal suspension in 6 per cent acacia. In one instance the colloidal suspension was administered in doses by the intracardiac route. Among other things, lard oil, sesame oil, and varying concentrations of acacia were also injected and their effects upon the animal and the tumor was noted. The following results were observed

- 1 The hydrocarbon 1 2 5 6 dibenzanthracene definitely inhibited this tumor (B, No 2) in every instance
- 2 Retene also inhibited it, but to a lesser degree. Whether or not retene is carcinogenic is not known, but a series of rats are being injected to determine this feature
- 3 Acacia did not inhibit
- 4 All animals treated intraperitoneally showed considerable damage to the viscera slight, with colloidal suspensions, marked, with sesame oil

solutions. Lard oil was prone to excite marked cellular proliferation and organization in the peritoneal cavity

- 5 The liver was always injured, even with minute doses of retene and dibenzanthracene given intracardiacally
- 6 When distilled sesame oil caused definite peritoneal irritation, it inhibited tumor growth, but there was no instance of inhibition with the household brand

It is, therefore, suggested that the inhibition of the sarcoma B, No 2, may have been due, in part, at least, to constitutional damage and that the effect of 1 2 5 6 dibenzanthracene is not specifically directed against the neoplasms

The author wishes to extend his thanks to Dr Newton Evans, Pathologic Department, Los Angeles General Hospital, and to Dr Roy Hammock for their assistance in diagnosing the microscopic sections, to Dr William H Woglom for reading the manuscript, and to his technical assistants, Patricia H O'Hara, M S, Anna Wiener, B S, and Margaret A Neely, R N, for their untiring co-operation

209 South Lake Street

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with nodules throughout the omentum. Extraction with ether yielded a solution which gave the characteristic fluorescence under ultra-violet light.

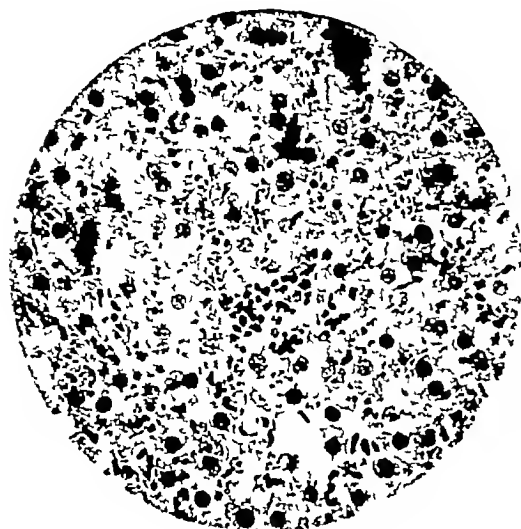


Fig. 8. Liver changes from intracardiac coloidal retene (450 \times hematoxylin-eosin).

Intraperitoneal administration of 1 2 5 6 dibenzanthracene in sesame oil. Series of Aug. 4, 1937 (Table XIV, p. 691).

Experiment 8—The effect of different volumes and concentrations of acacia solutions on the growth of B, No. 2, from various volumes of inoculum. Series of May 24, 1937. Nine animals.

from suspensions of 0.01 cc, 0.001 cc, 0.0001 cc, and 0.00001 cc. Nine rats were inoculated with tumor B, No. 2, suspension in the same manner as in Experiment 5. The following day eight were injected intraperitoneally with the solutions of acacia as above described, and one was left as control. The result indicated in Table XV shows that acacia solutions so given had no stimulating effect on the size of the tumors resulting from the various volumes of inoculum.

DISCUSSION

Since the presence of illness tends to inhibit the growth of tumors, the observation that certain carcinogenic compounds do the same thing without making the animal sick would be of great significance. But when the experiment was repeated by the author, considerable injury was noted not only in rats which received the hydrocarbons but in the sesame oil controls as well. However, it is still important to note that, as a rule, acacia and household sesame oil did not tend to inhibit tumor growth, while the addition of the hydrocarbons retene and 1 2 5 6 dibenzanthracene to these compounds did.

Twort and Lyth (7) noted that when 0.5 cc of various mineral oils were injected intraperitoneally into 20-gram mice, a portion was recoverable in one week and that the introduction was followed by

TABLE XV

Concentration of Acacia	6 Per Cent		12 Per Cent		25 Per Cent		50 Per Cent	
Volume of Acacia Injected	2 cc	5 cc	2 cc	5 cc	2 cc	5 cc	2 cc	5 cc
Total Wt. Tumor Tissue per Rat	17.4 gm	21.2 gm	22.7 gm	31.1 gm	28.1 gm	28.9 gm	44.4 gm	34.9 gm

Untreated Control Total wt. of tumor tissue 32.4 gm

It had been noted casually that animals which had been treated with acacia solution seemed to be a little heavier in weight. Therefore, it was decided to try the effect of acacia solutions without hydrocarbons in amounts of 2 and 5 cc, and in concentrations of 6 per cent, 12 per cent, 25 per cent, and 50 per cent on tumors grown

invasion of leukocytes, possible trapping of the oil and subsequent endothelial proliferation (peritonitis). They also found that painting mice with these oils caused fatty infiltration and hyaline degeneration of the liver.

Twort and Twort (8) found that painting mice with synthetic tar produced "a

BLOOD VESSEL MARKINGS IN THE DORSAL VERTEBRÆ SIMULATING FRACTURE¹

PRELIMINARY REPORT

By KENNETH S DAVIS, M S, M D, *Los Angeles*

From the X-ray Department, St Vincent's Hospital, and the School of Medicine, University of Southern California

IN these days with court litigation more concerned in regard to unnecessary detail than with the broader principles of anomaly of the dorsal vertebræ which has been at least once interpreted as fracture and as such was the basis of litigation

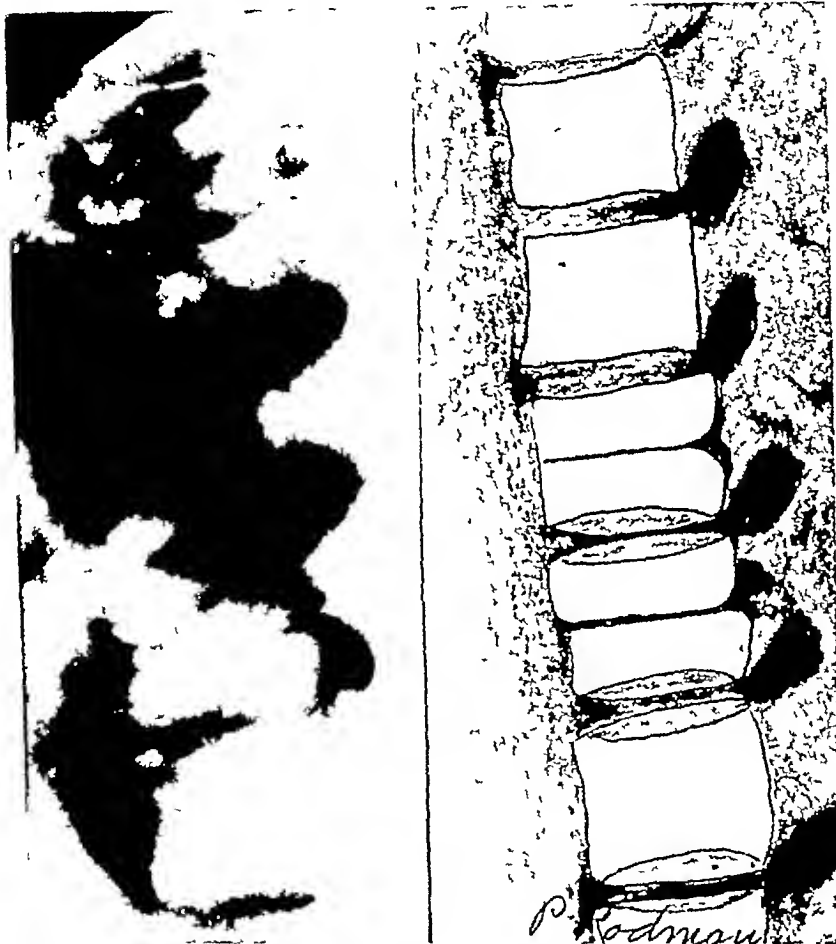


Fig 1 Lateral roentgenogram of the dorsal spine in a man who had sustained injury in a railroad accident. The ninth and tenth vertebrae show transverse linear marks bisecting the vertebræ into two symmetrical halves. The upper half of the body of the tenth dorsal lies fully 3 mm anterior to the lower half. This case brings up the interesting speculation of a divided vertebra, due either to failure of fusion of the primitive somites or to a persistence of the inter-segmental septum, with a possible displacement of the upper half of the body of the tenth dorsal as a result of the trauma. The twelfth dorsal, which was not included in this roentgenogram showed a compression fracture.

justice, it would seem wise to record an

¹ Presented before the Fifth International Congress of Radiology in Chicago Sept 13-17 1937

Our attention was first drawn to this anomaly when we were called into court to interpret roentgenograms made of the

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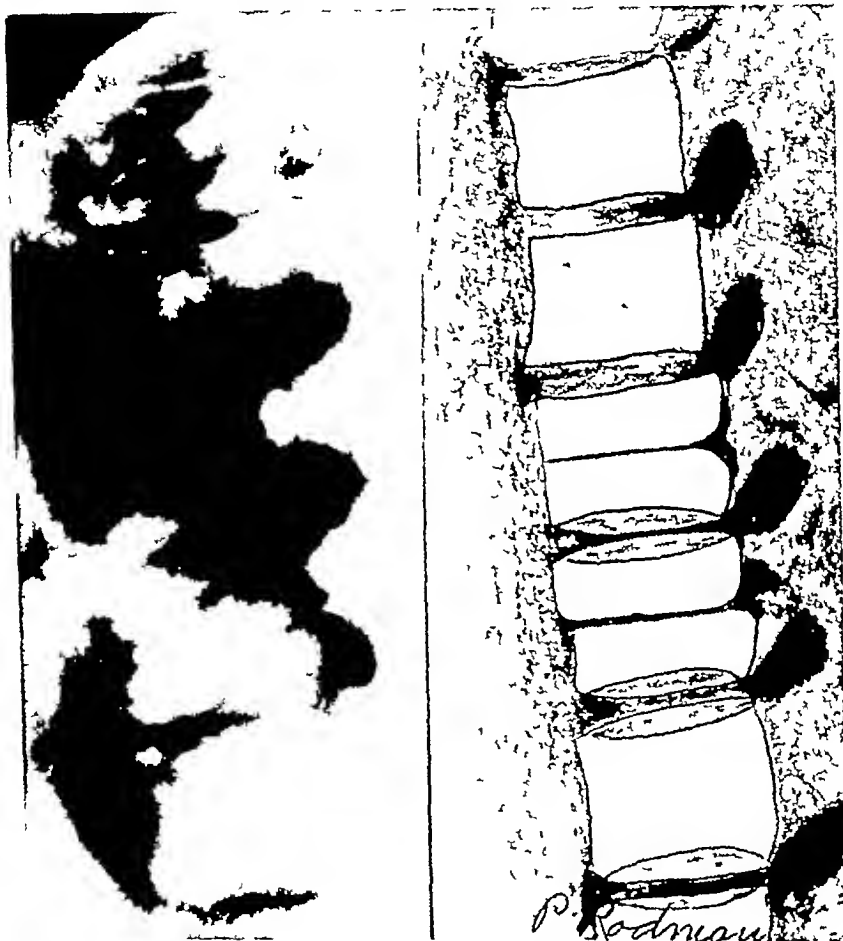


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Fig 2 Lateral roentgenogram of the dorsal vertebrae in a colored male, 42 years of age complaining of pain in neck and shoulders. No history of injury. On physical examination patient complains of tenderness on pressure over the spinous processes of the cervical and upper dorsal vertebrae. No tenderness could be elicited over the lower dorsal spine. This film illustrates the typical transverse linear marks in the dorsal vertebrae due to blood vessel channels in the vertebral body.

dorsal spine. These films showed definite transverse linear marks through the centers of the bodies of the ninth and tenth dorsal vertebrae, best seen in the lateral view but also demonstrable in the anteroposterior view. These lines apparently divided the body into two symmetrical halves, and in one of the roentgenograms the upper half of the body of the tenth dorsal apparently lay about 3 mm anterior

to the lower half (Fig 1). There was also a fracture through the anterior superior margin of the twelfth dorsal with a moderate compression of the anterior margin of the body as a result.

A careful review of the lateral roentgenograms of the dorsal vertebrae in our files showed 43 cases in which this anomaly existed. Since then, in viewing lateral films in this region, this transverse linear mark has been observed in about 10 per cent of all cases (Fig 2). It was seen in approximately the same percentage of non-traumatic cases as in those that had sustained trauma. These lines were found in persons from 20 to 76 years of age, the average age being about 42.

Being unable to obtain any postmortem material in our clinical cases, we secured the dorsal vertebrae from cadavers in the Department of Anatomy of the Medical School of the University of Southern California. Lateral roentgenograms of the removed spines showed an astonishingly high percentage of transverse linear marks in the dorsal vertebrae (approximately 22 per cent). The vertebrae showing these marks were then carefully dissected out and the blood vessels were injected with a mixture of barium and water. After injecting the blood vessels and taking anteroposterior, lateral, and longitudinal roentgenograms, the vertebrae were then sectioned, some transversely, some anteroposteriorly, and some longitudinally. These experiments revealed that the transverse linear marks were due to blood vessel channels in practically all instances (Figs 3, 4, 5, and 6). The injected channels were always found to enter the vertebral body in approximately the center of the *posterior vertebral body wall*, extending anteriorly into the body for varying distances. In no instance were we able to trace the channel through the anterior surface of the vertebral body although in some of the vertebrae the channel extended completely across the body (Fig 4).

We were never able to demonstrate blood vessels or blood vessel channels entering the body directly on the anterior surface

except for an occasional small anomalous vessel

Wagoner and Pendergrass (1), in their

main blood supply was received through branches from the anterior spinal artery which penetrates the body in the center of



Fig 3



Fig 4

Fig 3 Lateral and longitudinal roentgenograms of a dorsal vertebra before and after injection with barium and water. Note in the lateral view the notching of the *posterior* surface of the vertebral body at the point of emergence of the basi-vertebral veins.

Fig 4 In the lateral roentgenogram of this vertebra the transverse linear mark extended to the anterior surface of the body. A careful search failed to show any continuance of the channel to the exterior of the body on this surface.

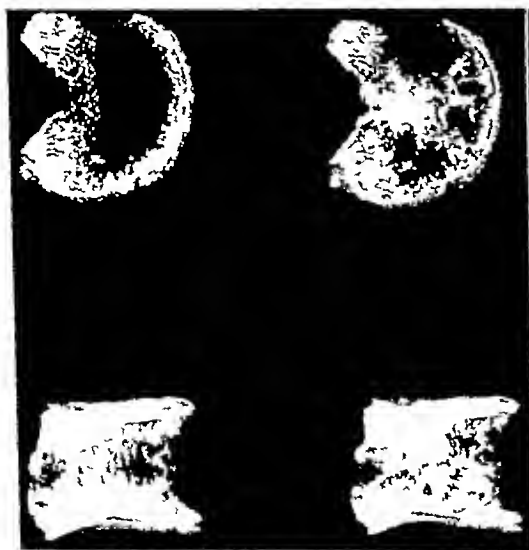


Fig 5

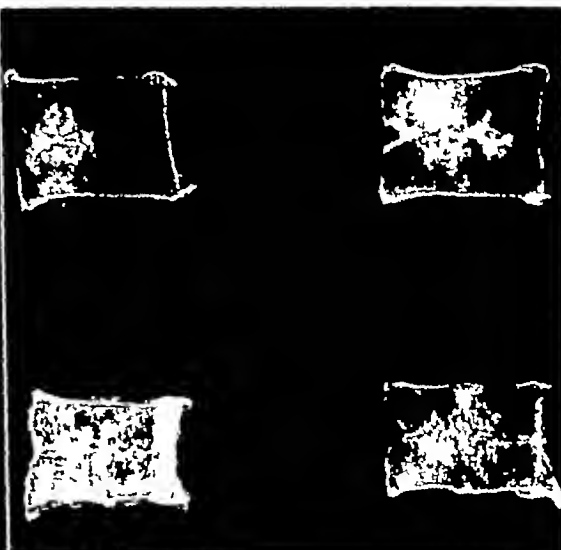


Fig 6

Fig 5 This illustrates the venous sinusoidal system as described by Wagoner and Pendergrass. The sinusoids are visible in the lateral film before injection.

Fig 6 Longitudinal sections through the vertebral bodies after injection. In one vertebra the blood vessel channel can be seen ending just beneath the anterior surface.

original research on the intrinsic circulation of the vertebral body found that the

the *posterior* vertebral body wall just above the exit of the basi-vertebral veins. These

arteries could be followed into the central substance of the vertebral body before dividing. They found that the vertebral

impossible to demonstrate this sinusoidal system on the roentgenograms of a normal adult spine.



Fig 7-A



Fig 7-B

Fig 7-C

Fig 7 C Lateral film in a three year-old child showing the translucent split

Fig 7 A Section through a fetal spine showing the three zones of osseous tissue as described by Hanson. The middle zone can be seen diminishing in its longitudinal measurements in the dorsal spine.

Fig 7-B A lateral roentgenogram of the spine in an infant age six months. In the dorsal region the middle transverse zone of osseous tissue is prominent. This zone could be seen not only in the lateral but in the anteroposterior view as well.

Fig 7 C Lateral film in a three year-old child showing the translucent split in the anterior part of the bodies of the dorsal vertebrae. Köhler states that this line is due to nutrient foramina but in my opinion it is a residual mark of the middle transverse zone of osseous tissue as described by Hanson.

bodies drained by four main venous trunks. Two leave the body—one on either side—antero-laterally just above the mid-line. Two emerge from the center of the posterior vertebral body wall and are commonly called the basi-vertebral veins. Within the body these four veins meet to form a large central reservoir or sinusoidal venous system. Wagoner and Pendergrass found it

Köhler (2), Hahn (8), and other German authorities (3, 5), have described a clear band-like translucent split extending from the middle of the anterior surface of the vertebral body into the body for varying distances. This finding was noted only in lateral roentgenograms of the spine in children and young adults. They attributed these lines to large nutrient foramina

and stated that the rarity of their appearance was due to the exceptionally rich blood supply of the vertebral bodies, which continues for only a short time in childhood and adolescence. Kohler states that these foramina are so large that one can pass an ordinary probe a good distance into the bone.

However, in our experimental work during which several hundred vertebral bodies were dissected we were never able to demonstrate any of these foramina. In fact, we were never able to find any blood vessels or blood vessel channels entering the body directly on the anterior surface except for an occasional small anomalous vessel.

Hanson (4), who first described the three zones of ossification in the spines of infants and young children, undoubtedly has given us a possible explanation for this "translucent split" on the anterior surface of the vertebral body during early life. The middle zone which is of lessened density in the roentgenogram consists of fully formed cancellous bone and contains fairly large blood vessel channels. This zone is routinely demonstrable in lateral roentgenograms of the spines of infants (Fig 7). Above and below this central zone are two layers of ossifying cartilage which form bone much more dense than the "middle zone." A persistence of the shadow of the middle zone might well account for the "translucent split" seen in the anterior portion of the bodies of the vertebræ in children as first described by Kohler and Hahn (Fig 8). No one has as yet observed the persistence of this notch or "split" in adult life. There is certainly no association of this *anterior "split"* with the translucent line seen in lateral roentgenograms of adult spines which are definitely blood vessel markings. These markings uniformly begin on the *posterior* margin of the body of the vertebræ, extending forward into the body for varying distances (Figs 3, 4, 5, and 6).

SUMMARY

- 1 In the great majority of cases trans-



Fig 8 Lateral roentgenogram of the dorsal vertebræ in a boy, seven years of age showing the anterior translucent "split" as described by Köhler and Hahn. This line is absolutely different in both location and appearance from the transverse linear marks seen in lateral films of the dorsal spine in adults; the latter being due to blood vessel channels. Compare with Figures 3, 4, 5, and 6.

verse translucent linear marks in the dorsal vertebræ seen in profile views of adults are due to blood vessel channels.

2 The blood vessels enter the vertebral body posteriorly and antero-laterally in the mid-line, *but they do not enter from the anterior surface.*

3 The notching or "split" in the anterior margins of the dorsal vertebral bodies in children is in all probability developmental, as has been described by Hanson.

4 The translucent line seen in lateral roentgenograms of adult spines is not associated with the notching and translucent "split" seen in the anterior margin of the vertebræ of infants and young children.

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Fig 7-A



Fig 7-B.

Fig 7-C

Fig 7. Lateral spine of a fetus, infant, and child respectively.

Fig 7-A. Section through a fetal spine showing the three zones of osseous tissue as described by Hanson. The middle zone can be seen diminishing in its longitudinal measurements in the dorsal spine.

Fig 7-B. A lateral roentgenogram of the spine in an infant, age six months. In the dorsal region the middle transverse zone of osseous tissue is prominent. This zone could be seen not only in the lateral but in the anteroposterior view as well.

Fig 7-C. Lateral film in a three-year-old child showing the translucent "split" in the anterior part of the bodies of the dorsal vertebrae. Köhler states that this line is due to nutrient foramina, but in my opinion it is a residual mark of the middle transverse zone of osseous tissue as described by Hanson.

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THE NECK¹

A ROENTGENOLOGIC STUDY

By SAMUEL BROWN, M D, J E McCARTHY, M D, and H G REINEKE, M D,
Cincinnati, Ohio

From the Jewish, Good Samaritan, and General Hospitals

It is a generally accepted truth that a knowledge of anatomy and physiology of a structure constitutes the basis for a diagnosis. It is for this reason that much space will be allotted to a discussion of the roentgen anatomy and physiology of the soft structures of the neck.

A review of the literature of the roentgenologic study of the neck reveals three periods of activity. The first, beginning with the discovery of the x-ray to the year 1914, was characterized by considerable interest in the roentgen study of the soft structures. From 1914 to 1927, the literature was barren in reference to this subject. From 1927 on, numerous valuable scientific contributions have been made.

During the first period a great deal of importance was attached to the diagnosis of foreign bodies lodged in the food and air passages. This is exemplified by the following statement by Carl Beck (1), in 1904, in one of the earliest text-books on the roentgen ray: "If the roentgen rays had done nothing else but locate foreign bodies in the throat, they would represent one of the greatest blessings to suffering humanity." In the same text-book the author discusses the diagnosis of aneurysms of the carotid and subclavian arteries, tumors of the larynx, goiter, and concretions in the submaxillary glands. Sinclair Tousey (2), another American author of an early roentgen-ray text-book, in 1910 discussed the roentgen anatomy of the larynx and various diseases of the neck diagnosed by the x-rays. Among the important contributions to the advancement of our knowledge of the roentgenology of the neck of this period are those of Frankel

(3), Scheier (4), Thost (5), and Iglauer (6). A great deal of credit is due these men for developing x-ray technic, the description of the roentgen anatomy and physiology of the soft parts, and the diagnosis of abnormal changes affecting the latter. All this was accomplished in spite of the limitations of the apparatus of that time. In the second period nothing was added to our knowledge. There was but one contribution and that by Pfahler (7), who described a new roentgenographic technic for the study of the thyroid gland.

The third period is rich in many original scientific contributions. Mosher (8) discussed the movement of the tongue, epiglottis, and hyoid bone during swallowing. One year later (1928) Brown and Reineke (9) published a paper dealing with the roentgen anatomy of the soft structures of the neck and the diagnosis of various affections. This paper was characterized by Pancoast as "a preface to the roentgenologic study of the neck." This was later (1930) supplemented by another paper (10) which dealt with the superior and posterior mediastina and some affections of the neck. In the same year (1928) Hickey (11) contributed an invaluable paper on the normal anatomy of the larynx in which he emphasized the importance of placing the film close to the neck in order to obtain better detail. In 1930 Hay's (12) excellent monograph appeared, which, by the way, has been a constant companion in our studies. In the same year Barclay (13) contributed a paper on the normal mechanism of swallowing and later discussed the same subject in his monograph (14) on the digestive tract (1933). In 1930 Pancoast (15) published a highly scientific paper dealing with the roentgenology of the upper re-

¹ Read before the Fifth International Congress of Radiology, Chicago, Sept. 12-17, 1937.

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blood vessels, nerves, glands, and fascia. The recently introduced pneumofasciagram of Gratz (31) may prove of service, but, so far, we have not made use of this method. We do have several cases of spontaneous pneumofasciagrams as a result of accidents which have proven instructive in differentiating some of the soft structures.

THE ROENTGEN ANATOMY AND PHYSIOLOGY OF THE NECK

In general, the neck has the shape of an oblique cylinder linking together the head above and the thorax below. The upper and lower boundaries of the neck are on a lower level anteriorly than posteriorly, so that there is a considerable superimposition of the structures in the anteroposterior view, the upper region of the neck being overlapped by the facial structures, the lower by the thoracic. The length and thickness of the neck depend upon the age of the individual and his habitus. Individuals of the asthenic type have long and narrow necks, of the sthenic type, short and broad. In infants the neck is usually short, and, relatively speaking, broad. The internal structures of the neck generally conform in length and breadth to that of the external.

The structures of the neck which can be identified by the x-ray are as follows: (1) cervical spine, (2) muscles, subcutaneous tissue, and skin, (3) prevertebral fascia, (4) posterior pharyngeal wall, (5) naso-, oro-, and laryngo-pharynx, (6) soft palate and uvula, (7) passage between mouth and pharynx, (8) base of tongue and lingual tonsil; (9) mandible and hyoid bone, (10) epiglottic vallecula and epiglottis, (11) aryepiglottic folds and arytenoid cartilages, (12) laryngeal vestibule, (13) ventricular folds, (14) vocal cords, (15) thyroid cartilage, (16) cricoid cartilage, (17) trachea, (18) pyriform sinuses, (19) esophagus, (20) tonsils, (21) glands, chiefly the thyroid.

In the anteroposterior position (Fig 1) the cervical spine occupies about the middle third of the roentgenogram. On

each side of the spine there is a column of undifferentiated soft tissue consisting of muscles, blood vessels, nerves, and glands. In a pneumofasciagram of the neck (Figs 2 and 3) some of the muscle layers can be differentiated by the intervening air in the fascial planes. Superimposed upon the spine are a number of important structures which, however, cannot be recognized. The trachea, because it is air-containing, is readily differentiated. It is located in the median plane in front of the spine, commencing at the level of the body of the fifth cervical vertebra when at rest, and extending downward into the thoracic cavity. Above, the walls of the trachea gradually converge resembling a cone, the apex of which corresponds to the region of the true vocal cords. On each side of the tracheal cone the alae of the thyroid cartilage are often recognized when they are ossified. They lie at the periphery of the cervical vertebrae, gradually diverging in their upward course. The end of the tracheal cone is located in the center of the so-called thyroid cartilage box. The pharynx and esophagus cannot be recognized on a plain anteroposterior view unless barium or other opaque medium is swallowed (Fig 4). The lumen of the pharynx appears to be rather broad from side to side, but below the fifth cervical vertebra it abruptly narrows in its downward passage. This narrowing corresponds to the lumen of the cervical portion of the esophagus.

In the lateral position of the neck (Fig 5) the cervical spine again occupies approximately the middle third. Behind the spine there is a layer of soft tissue which can be differentiated into three zones on account of slight variation in their density, corresponding to the skin, subcutaneous fatty tissue, and muscles.

In front of the spine there are several important structures: the pharynx, larynx, trachea, esophagus, hyoid bone, base of the tongue, soft palate, and tonsils. These are readily differentiated because some of them are air-containing, while the others are dense enough to make them stand out in contrast to the former.

spiratory tract, with special reference to the larynx and adjacent structures. Together with Pendergrass (16) he presented a paper concerning the roentgenologic diagnosis of diseases of the upper respiratory tract in children. In 1933 Pancoast (17) presented an excellent contribution dealing with the roentgenology of the pharynx and cervical esophagus. Jackson (18 and 19) contributed (1930 and 1936) valuable papers on the soft structures of the neck. Pack and Craver (20) discussed at length the diagnosis and treatment of tumors of the larynx and thyroid (1931). An evaluation of roentgenology in otolaryngology was presented by Golden (21) in 1933. The following year Jönsson (22) described a new method for roentgen examination of the hypopharynx and upper air passages, which consisted in making use of the Valsalva experiment. This has proven to be valuable in our work. In the same year Hirsch and Baum (23) contributed an elaborate study on the roentgen diagnosis and treatment of laryngeal tumors. The following year (1935) Chamberlain and Young (24) published a paper on the ossification of the normal laryngeal cartilages. Recently (1936) there has appeared a valuable paper by Taylor (25) in which he discusses ossification of the laryngeal cartilages under normal and abnormal conditions.

Among the many who contributed papers on the diagnosis of foreign bodies in the throat, those of Iglauer and Ransohoff (26) in 1924, Tucker (27) in 1925, and Manges (28 and 29) from 1927 to 1929 are outstanding, for the principles of diagnosis that they developed can be applied in many diverse situations.

In this paper it is planned to incorporate the knowledge gained from the study of the above contributions with our own observation of many years of the roentgen anatomy and physiology of the neck under normal and abnormal conditions.

X-RAY TECHNIC

Great improvements have taken place in the character of the roentgenograms of

the neck resulting from several factors, namely, increased milliamperage and kilovoltage, greater distances and shorter exposures, so that it is now possible to obtain sharply defined roentgenograms. During the past few years, with few exceptions, we have used the same technic for the neck as for the thorax: 70-80 kv, 60 ma, 6 feet distance, time, about one-half to one second, in the sitting position. This technic is modified in the case of infants and children whose co-operation is generally hard to obtain. Under these conditions, we use the horizontal position which is more adapted for the proper immobilization of the neck and a shorter distance. In general, relatively good diagnostic roentgenograms are obtained. For patients who are too ill to sit up the recumbent position is also necessarily used.

For the lateral view of the neck we make use of Grandy's (30) technic for the cervical spine, which consists in having either shoulder resting against the vertical cassette changer. The head and neck are held parallel to the cassette and are steadied by an assistant. The patient is instructed to hold the breath and not to swallow during the exposure. When the movements of the pharynx, larynx, trachea, tongue, hyoid bone, and soft palate are desired to be demonstrated, the patient is instructed to go through the motions of the act of swallowing, phonation, or respiration, and remain in that state during the x-ray exposure. For the anteroposterior view the same factors are used with the exception that the dorsal surface of the neck rests against the cassette. At times we find it preferable to use the horizontal position for the anteroposterior view, together with the Potter-Bucky diaphragm.

The roentgenograms of the neck obtained with the above technic have been highly satisfactory. The soft structures are sharply outlined, and any abnormal change is readily recognized. So far, no attempt has been made to differentiate those structures which lie laterally and posteriorly to the cervical spine—muscles,

above at the base of the cranium and gradually narrows to the level of the larynx, known as the pyriform sinuses, and then rapidly narrows to its termination. Posteriorly, the wall of the pharynx is complete and lies anterior to the upper six cervical vertebræ, being separated from the latter by the prevertebral fascia and muscles. The thickness of these structures varies, being wider above than below, and wider in infants and young children than in adults. Anteriorly the pharynx communicates with the nasal cavities, mouth, and larynx. Between the naso- and oro-pharynx project the soft palate and uvula, which under ordinary conditions rest upon the dorsum of the tongue. During phonation or deglutition they become elevated, assuming the shape of a hammer-toe, thus separating the naso-pharynx above from the oro-pharynx below and preventing food from entering the upper cavity. The oro-pharynx lies posteriorly to the mouth and tongue, the latter of which forms its anterior wall. The laryngeal portion of the pharynx communicates with the larynx, and its anterior boundary is formed by the epiglottis and the posterior surfaces of the arytenoid and cricoid cartilages. The naso-pharynx remains patent at all times and changes its size but little. The transparency of this cavity is, however, less marked than in the other sections on account of the overlapping of the ramus of the mandible and parotid glands. Occasionally one may see the styloid processes and the stylo-hyoid ligaments which, when calcified, cross the cavity diagonally (Fig 6). The oro- and laryngo-pharynx have considerable latitude in their capacity to expand, thus altering more or less in their shape and size. Under ordinary respiration there is little change, but during forced expiration or inspiration the cavity diminishes or increases, respectively. During swallowing the pharyngeal cavity is almost entirely obliterated (Fig 7). This is brought about by the contraction of the pharyngeal muscles, the backward displacement of the tongue, and elevation of the larynx. During the

phonation of certain vowels, such as "Ä" (Fig 8), the cavity somewhat diminishes, while in the pronunciation of "E" (Fig 9) the cavity increases. During the Valsalva experiment, which consists of forced expiration after a deep inspiration with the nose and mouth closed, the cavity enlarges considerably. In addition, air may be noted in the esophagus extending to the level of the crico-pharyngeus muscle (Fig 10).

The cervical portion of the esophagus begins at the level of the cricoid cartilage and extends downward in front of the cervical vertebræ. The lumen of the esophagus is only a potential one and is visualized during the passage of an opaque material. Otherwise its position is recognized by a column of non-differentiated soft tissue about one centimeter in width between the spine and trachea. Ordinarily its thickness does not exceed two-thirds of the anteroposterior diameter of the body of the sixth cervical vertebra.

The visualization of the pharynx and upper end of the esophagus by an opaque medium on a roentgenogram is rather difficult because of the rapid passage of the food. We have succeeded in some cases of pharyngitis in which the passage of food was delayed (Figs 11 and 12). Fluoroscopically the process of deglutition is readily observed. When the bolus of food is swallowed the soft palate is elevated up to a horizontal position and, so-to-speak, closes the naso-pharyngeal opening. The food is seen to travel along the curvature of the dorsum of the tongue until it reaches the vallecula, the depression between the dorsum of the tongue and the epiglottis. At once the larynx and hyoid bone ascend and the epiglottis turns backward and downward so that the bolus is directed to the posterior and lower portion of the pharynx into the pyriform sinuses and thence into the esophagus.

THE TONSILS

Between the angle of the mandible and the cervical spine there is occasionally

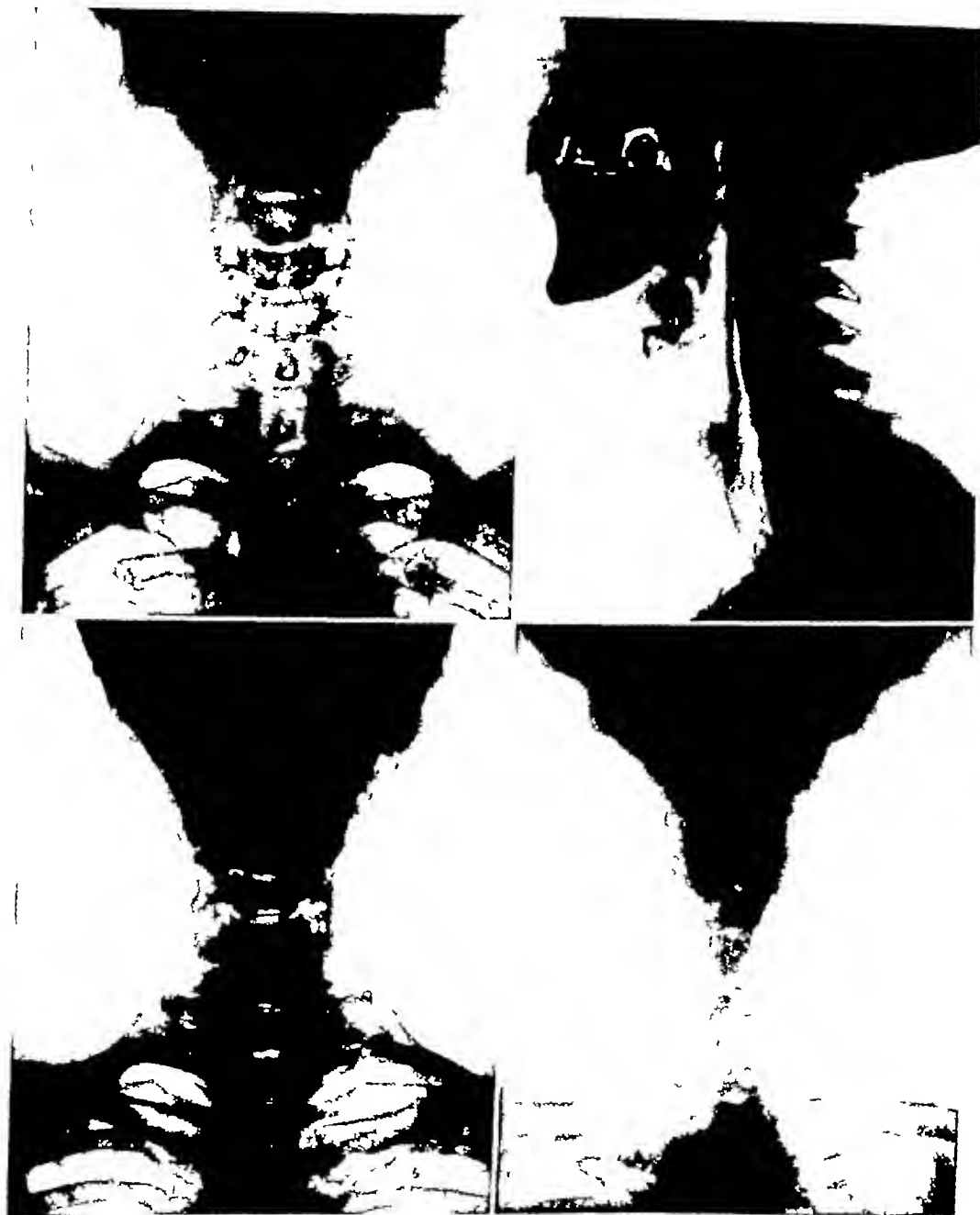


Fig 1 (*upper left*) Dorsal view The trachea is distinctly outlined The upper end is shaped like a cone, the apex of which corresponds to the true vocal cords At the periphery of the spine there is noted the ossified alae of the thyroid cartilage

Fig 2 (*upper right*) Lateral view Spontaneous pneumofasciogram as a result of traumatism Note the free air between the posterior wall of the pharynx and prevertebral fascia

Fig 3 (*lower left*) Anterior view The same case Note the free air along the fascial planes

Fig 4 (*lower right*) Anterior view Barium filled pharynx and esophagus The pharynx is broad the esophagus is narrow

The pharynx extends from the base of the sixth cervical vertebra, where it is continuous with the esophagus. It is widest at the cranium to the level of the body of the

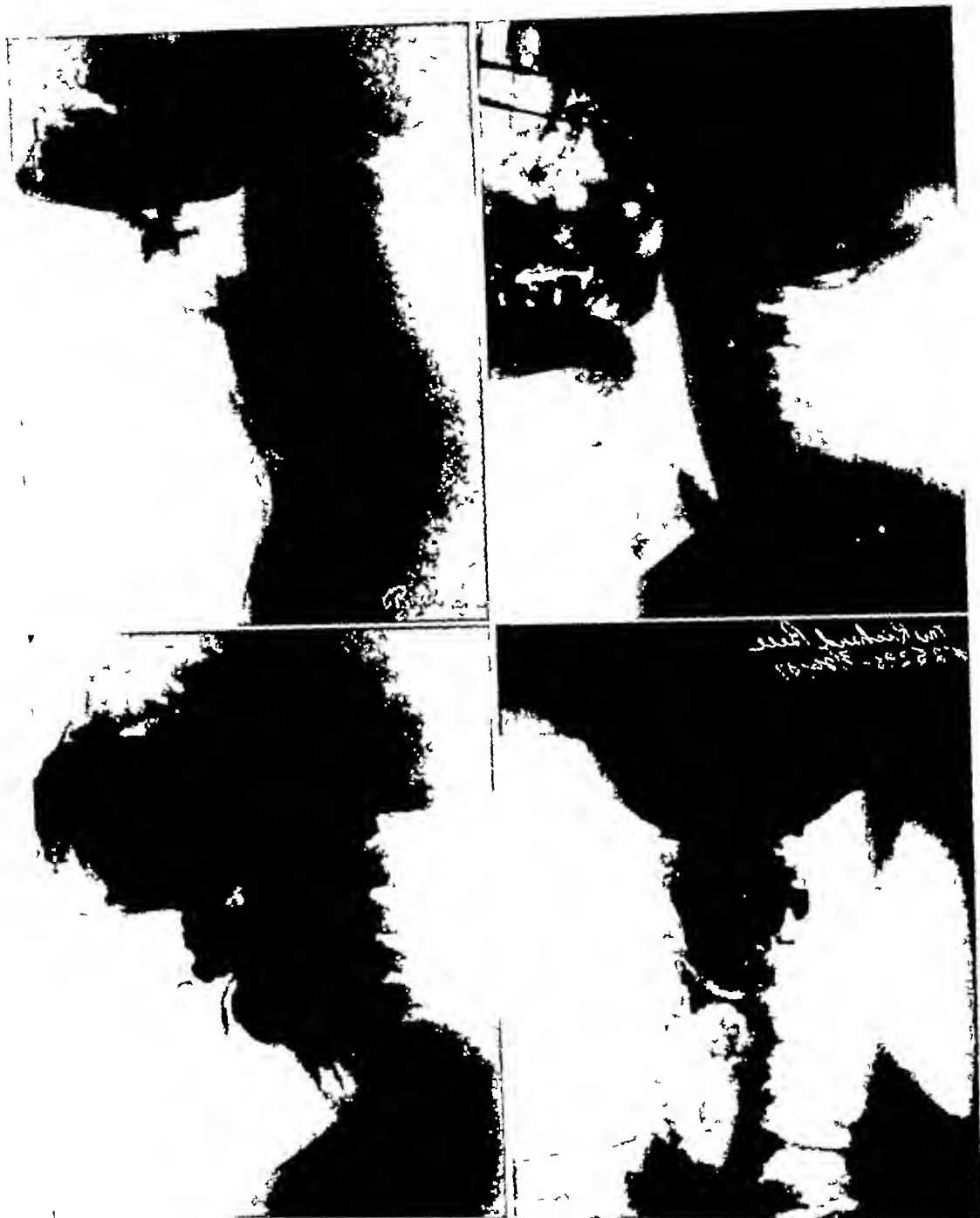


Fig 9 (upper left) Lateral view The pharyngeal cavity is greatly increased during the phonation of the vowel 'E' Note the forward displacement of the tongue and epiglottis also the opening of the ventricle

Fig 10 (upper right) Lateral view Valsalva experiment The pharynx is dilated Note the air in the upper end of the esophagus

Fig 11 (lower left) Lateral view The pharynx is filled with barium Note the barium in the vallecule and pyriform sinuses

Fig 12 (lower right) Anterior view Note the barium filled vallecule which is separated by the glosso-epiglottic fold into two pouches The pyriform sinuses are filled with barium

and anterior part of the neck, below the hyoid bone and tongue and continuous with the trachea below Its position is not fixed, being freely movable during the act

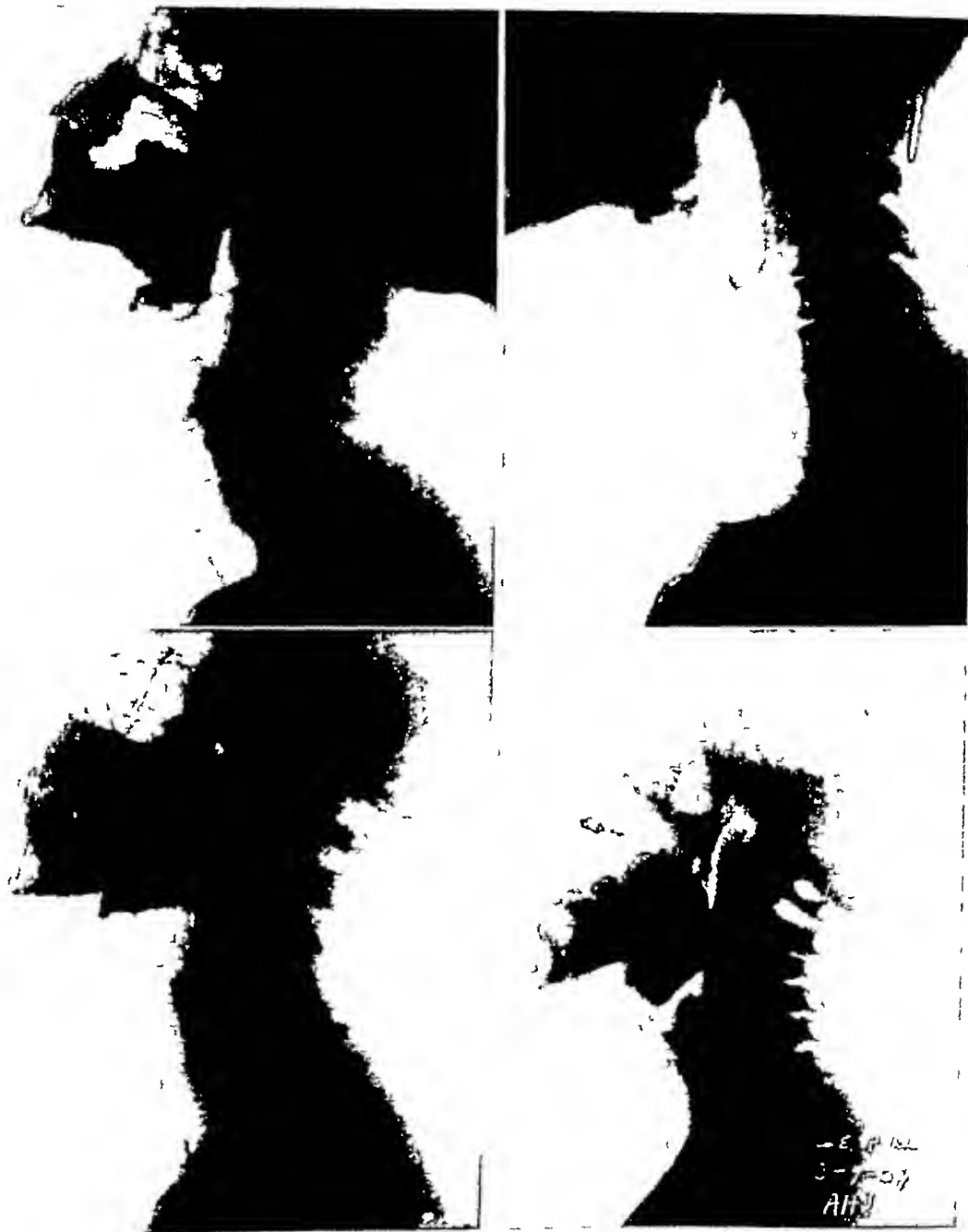


Fig 5 (upper left) Lateral view The pharynx is outlined in its entire course The laryngeal cartilages are uniformly ossified (male)

Fig 6 (upper right) Lateral view The stylohyoid ligament is ossified and is shown between the hyoid bone and styloid process

Fig 7 (lower left) Lateral view The pharyngeal cavity is obliterated during the act of swallowing Note the elevation of the hyoid bone and larynx

Fig 8 (lower right) Lateral view The pharyngeal cavity is greatly diminished in size during phonation of the vowel 'A' Note the backward displacement of the tongue

noted an oval-shaped shadow in the pharynx which is due to the tonsils (Fig 13)

THE LARYNX

The larynx (Fig 14) occupies the upper

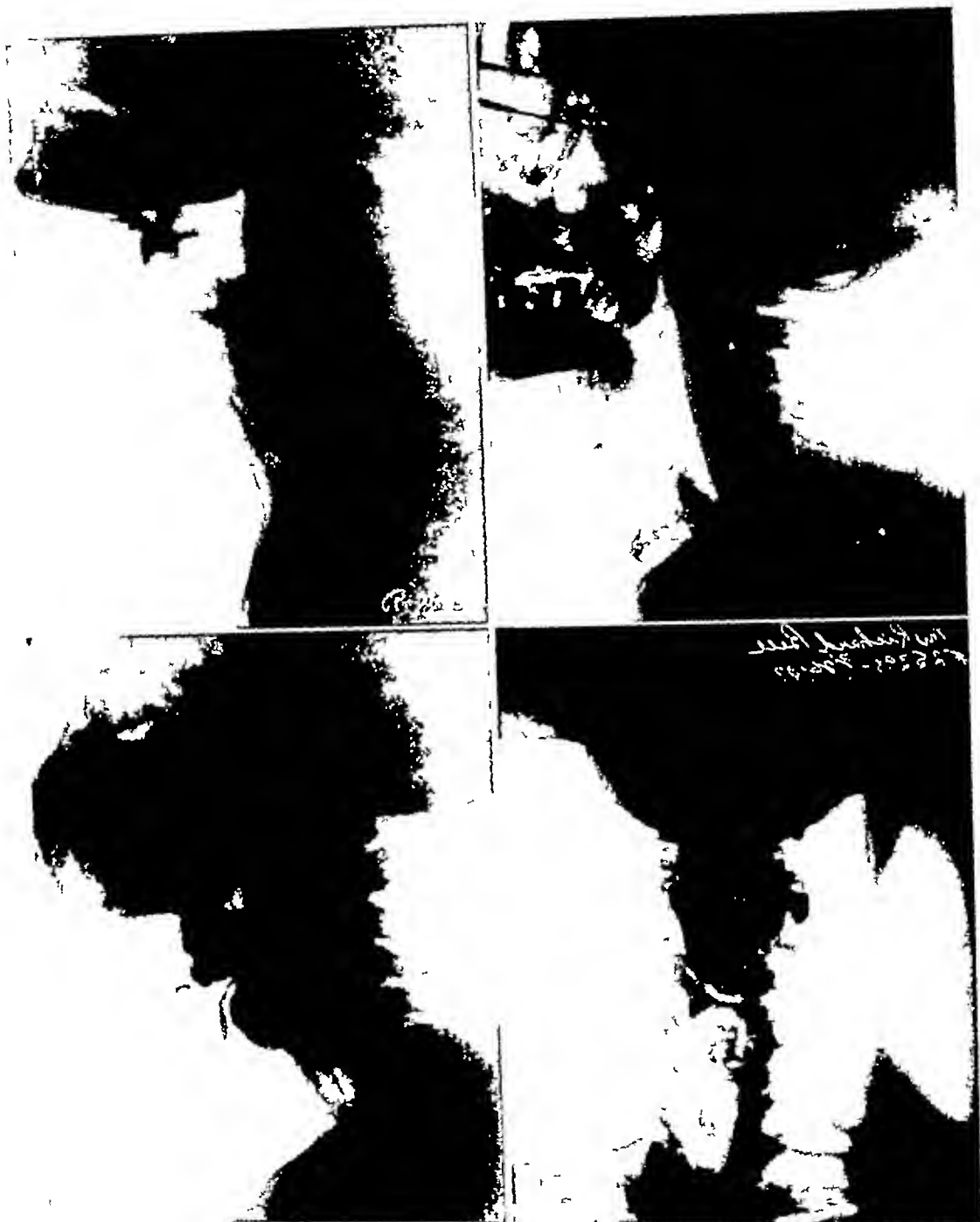


Fig 9 (upper left) Lateral view The pharyngeal cavity is greatly increased during the phonation of the vowel 'E' Note the forward displacement of the tongue and epiglottis also the opening of the ventricle

Fig 10 (upper right) Lateral view Valsalva experiment The pharynx is dilated Note the air in the upper end of the esophagus

Fig 11 (lower left) Lateral view The pharynx is filled with barium Note the barium in the vallecula and pyriform sinuses

Fig 12 (lower right) Anterior view Note the barium filled vallecula which is separated by the glosso-epiglottic fold into two pouches The pyriform sinuses are filled with barium

and anterior part of the neck, below the hyoid bone and tongue and continuous with the trachea below Its position is not fixed, being freely movable during the act

of swallowing. The larynx is divided into three portions, upper, middle, and lower. The upper, known as the vestibule, extends from the superior opening of the larynx to the ventricular folds, its width diminishing from above downward. Anteriorly it is bounded by the posterior surface of the epiglottic and thyro-epiglottic ligaments. Each lateral wall of the vestibule is formed by the aryepiglottic fold. The posterior wall of the vestibule is narrow and corresponds to the interval between the upper part of the arytenoid cartilages. The epiglottis projects upward to the root of the tongue. Its movements during phonation and deglutition determine the size of the vallecula. The middle subdivision of the laryngeal cavity is very small and is bounded above by the ventricular folds and below by the vocal cords. These folds are frequently visualized, more often in the female than in the male and before complete ossification of the cartilages has occurred. Anteriorly and posteriorly the folds join, forming commissures, and extend from the thyroid cartilages in front to the arytenoid cartilages behind, being attached laterally to the laryngeal walls. The size of the ventricle between the folds varies, depending upon phonation—the enunciation of "E" widens it considerably. The rima glottidis cannot be recognized on the roentgenograms. The lower subdivision of the laryngeal cavity extends from below the true vocal cords to the trachea.

The thyroid cartilage is the largest one of the larynx. It consists of two broad plates, termed *alæ*, which meet anteriorly at an angle and become fused along the median plane. Posteriorly the *alæ* diverge from each other, and terminate above and below by slender projections known as the cornua. The superior cornu is attached to the cornu of the hyoid bone by a ligament. Midway between the cornu of the thyroid cartilage and the cornu of the hyoid is the cartilage *triticea* which, when ossified, can readily be visualized. Its existence should be kept in mind as it may be confused with foreign bodies.

The cricoid has the shape of a signet ring, being narrow anteriorly and broad posteriorly. The superior border articulates posteriorly with the arytenoid cartilages. The lateral surfaces of the cricoid articulate with the inferior cornua of the thyroid cartilage. At times a small hook-like projection is noted behind the posterior surface of the cricoid, which may be occasionally mistaken for a foreign body. At times it is possible to identify the corniculate and cuneiform cartilages when ossified.

The trachea is a wide patent tube held in this shape by cartilaginous rings embedded in its walls. Being deficient in cartilage posteriorly the anterior portion is visualized only when the rings ossify. In the neck the trachea is in the median plane, anterior to the esophagus and in contact with the lobes of the thyroid gland laterally. The trachea is not rigid, its length and breadth vary, depending upon the force of inspiration. This can be demonstrated by the Valsalva experiment.

Ossification of the laryngeal cartilages usually begins at the end of the second decade. The cricoid is the first to show signs of ossification, and is followed by gradual ossification of the thyroid. The degree of opacity of the larynx depends upon the ossification of its constituent parts. In general, no definite rule can be drawn as regards the exact time, form, and degree of ossification on account of a marked variation in different individuals, within normal limits.

The thyroid gland can often be recognized by a slight bulge of the soft tissue in front of the trachea, but its exact outline cannot be made out.

The hyoid bone is located under the mandible. It consists of a body and two cornua which in adults unite to form one bone. The cornua cross the pharynx anteroposteriorly and are parallel to the mandible. The hyoid bone is freely movable, especially during the process of deglutition.

DISEASES OF THE NECK

The Cervical Spine—We are not primarily interested in the spine, except insofar as it may affect the soft structures of the neck. It should be studied both in the anteroposterior and lateral positions. Fractures, dislocations, and hypertrophic changes will often alter the normal contour of the pharynx and esophagus. Newgrowths of the spine, either primary or secondary, were also noted to affect the relationship of the adjacent structures. In a case of neurofibroma there was considerable distortion of both the hard and soft structures of the neck. Tuberculous lesions of the spine may produce considerable distortion of the posterior wall of the pharynx because of the secondary formation of a chronic retropharyngeal abscess (Fig 15).

The Pharynx—The most important lesions of the pharynx are tumors, benign and malignant, and acute retropharyngeal abscesses. Tumors in the retropharyngeal region are recognized by more or less obliteration of the cavity by a shadow of soft consistence. Of course, the exact nature of the tumor cannot be determined.

Retropharyngeal abscess of the acute type is readily recognized by the widened space between the spine and posterior pharyngeal wall (Fig 16). Such an abscess may involve the entire space and at times extend into the posterior mediastinum. The pharynx, larynx, and trachea are displaced forward—the degree depends upon the size of the abscess. The presence of an air bubble in the retropharyngeal space is pathognomonic of an abscess and is invariably due to a perforation by a foreign body. Swelling of the retropharyngeal space is not always due to tumors or abscesses and may be the result of a cellulitis. One of the largest swellings we have encountered was due to the latter.

Tumors arising from the anterior boundary of the pharynx are usually of nasal or oral origin. Carcinoma of the base of the tongue produces a deformity of its pharyngeal wall and often extends to the val-

lecula. This can be demonstrated more satisfactorily by an opaque medium. The epiglottis is often found to be thickened and not freely movable.

Acute or chronic pharyngitis shows, in general, swelling of the mucous membrane (Fig 17). Dysphagia is quite marked and the passage of food is impeded, thus enabling one to visualize the pharynx by means of an opaque medium.

Esophagus (Cervical Portion)—Pharyngeal diverticula are the most frequent affections met with in the region of the cervical portion of the esophagus. They usually arise at the junction between the pharynx and esophagus. In the lateral position of the neck it is often possible to recognize the lesion even without the ingestion of an opaque medium if a fluid level accompanies the widening between the spine and the trachea (Fig 18).

Pharyngoceles occur infrequently. They are best demonstrated in the anteroposterior position during a Valsalva experiment (Fig 19).

Newgrowths of the cervical portion of the esophagus rarely occur. When present, they are demonstrated by the deformity produced in the lumen as shown by the opaque medium. Occasionally there is almost complete obstruction and no barium can enter. In these cases one will often notice a widening of the space between the spine and trachea due to the tumor.

The Larynx—Acute or chronic laryngitis can be recognized by the increased thickness of the epiglottis, arytenoid cartilages, and aryteno-epiglottic folds (Fig 20).

In advanced carcinoma of the larynx the outline of the various structures comprising the larynx is poorly defined. Areas of increased transparency due to absorption of the ossified cartilaginous tissue may be recognized. The vocal cords are seldom demonstrated (Fig 21).

Papillomas of the larynx can often be visualized on account of the sharpness of their outline on the transparent background. A case of a benign papilloma on the vocal cord was demonstrated only after the opening of the ventricle follow-



Fig 13 (*upper left*) Lateral view The oval shaped shadow behind the angle of the jaw is apparently due to an enlarged tonsil. In re-examination after surgical removal the shadow was no longer seen

Fig 14 (*upper right*) Lateral view The laryngeal cartilages are not uniformly ossified This is frequently the case in females

Fig 15 (*lower left*) Lateral view Tuberculosis of the spine with a large retropharyngeal abscess

Fig 16 (*lower right*) Lateral view Large retropharyngeal abscess Note the air bubble which is pathognomonic of a perforation. Also note foreign body adjacent to the air bubble

ing the enunciation of the vowel "E"
(Figs 22-A and 22-B)

Extrinsic tumors are not difficult to
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Fig 17 (*upper left*) Lateral view Acute pharyngitis Note the thickening of the posterior wall of the pharynx and epiglottis

Fig 18 (*upper right*) Lateral view Pharyngeal diverticulum Note the widening between the trachea and spine also fluid level with air above it

Fig 19 (*lower left*) Anterior view Pharyngoceles Note the air bubbles at the periphery of the spine below the mandible Their demonstration is accomplished by the Valsalva experiment

Fig 20 (*lower right*) Lateral view Chronic laryngitis Note the thickening of the epiglottis

eral position, the larynx and trachea are displaced forward After the ingestion of barium the dislocation of the esophagus can be demonstrated



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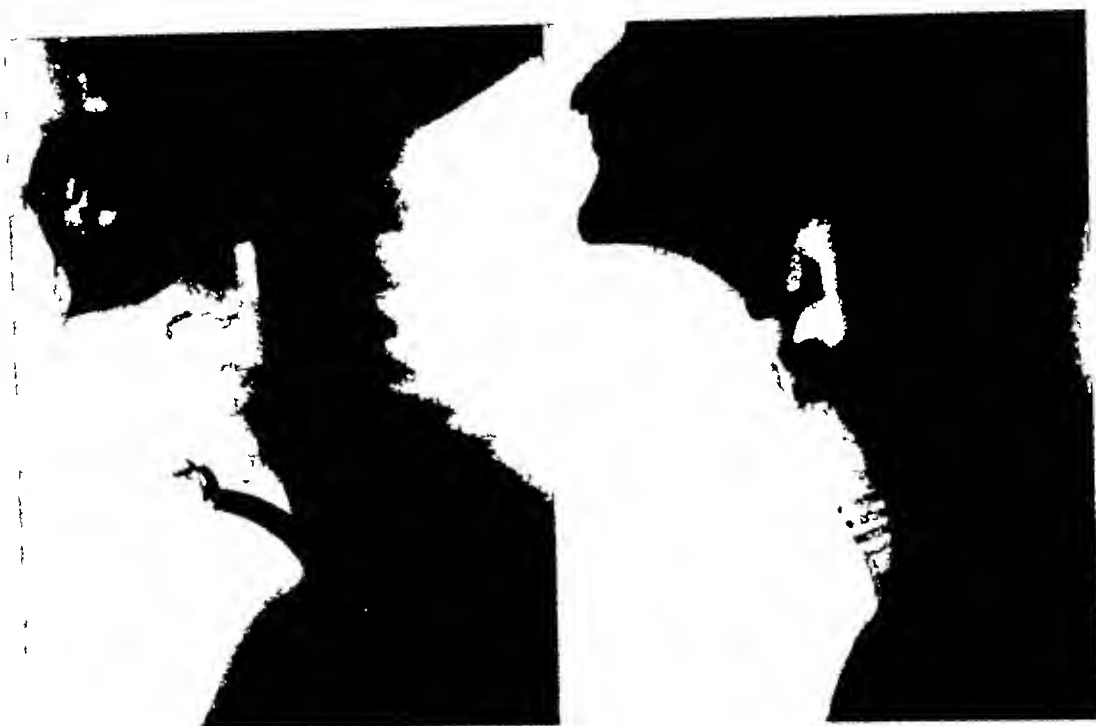


Fig 24 (left) Lateral view Laryngeal stenosis due to diphtheria Note the excessive ossification of the laryngeal cartilages Male 25 years of age

Fig 25 (right) Lateral view Note the marked excessive ossification of the laryngeal cartilages and tracheal rings, believed to be due to x-ray treatment for a goiter A high degree of telangiectasis was also present

the early roentgenologic changes In one, the epiglottis and arytenoid cartilages were found quite edematous The laryngoscopic diagnosis was that of tuberculosis A case of advanced pulmonary tuberculosis with laryngeal involvement showed swelling of the arytenoid region, with fragmentation of the ossified laryngeal cartilages and more or less general distortion of outline (Fig 23)

Laryngeal Diphtheria—We have had no acute cases of laryngeal diphtheria in our series, but several chronic cases with stenosis In one case we noticed a rather advanced ossification of the laryngeal cartilages for the age of the individual, who was only 25 years of age (Fig 24) This confirms Taylor's observation that chronic infection predisposes one to excessive bone formation in the laryngeal cartilages

The Trachea—We have had, so far, very little experience in the diagnosis of primary lesions of the trachea, which are

known to be rare, but since its outline is so well defined anything encroaching upon its lumen should offer no difficulty in demonstration Secondary changes as a result of laryngeal affections, such as tracheal stenosis, have been encountered Alterations in the position and caliber of the trachea have been observed quite frequently, as a result of tumors of the neck, especially those arising from the thyroid Recently an interesting case came under our observation which showed changes in the tracheal rings with markedly increased ossification of both the laryngeal and tracheal cartilages We are inclined to attribute these changes to x-ray treatment given for a goiter many years before Externally the neck shows a high degree of telangiectasis (Fig 25)

Thyroid Gland—The normal thyroid gland is not readily differentiated on the roentgenogram When enlarged, it is recognized as a mass of soft tissue projecting in front of the trachea The latter is often

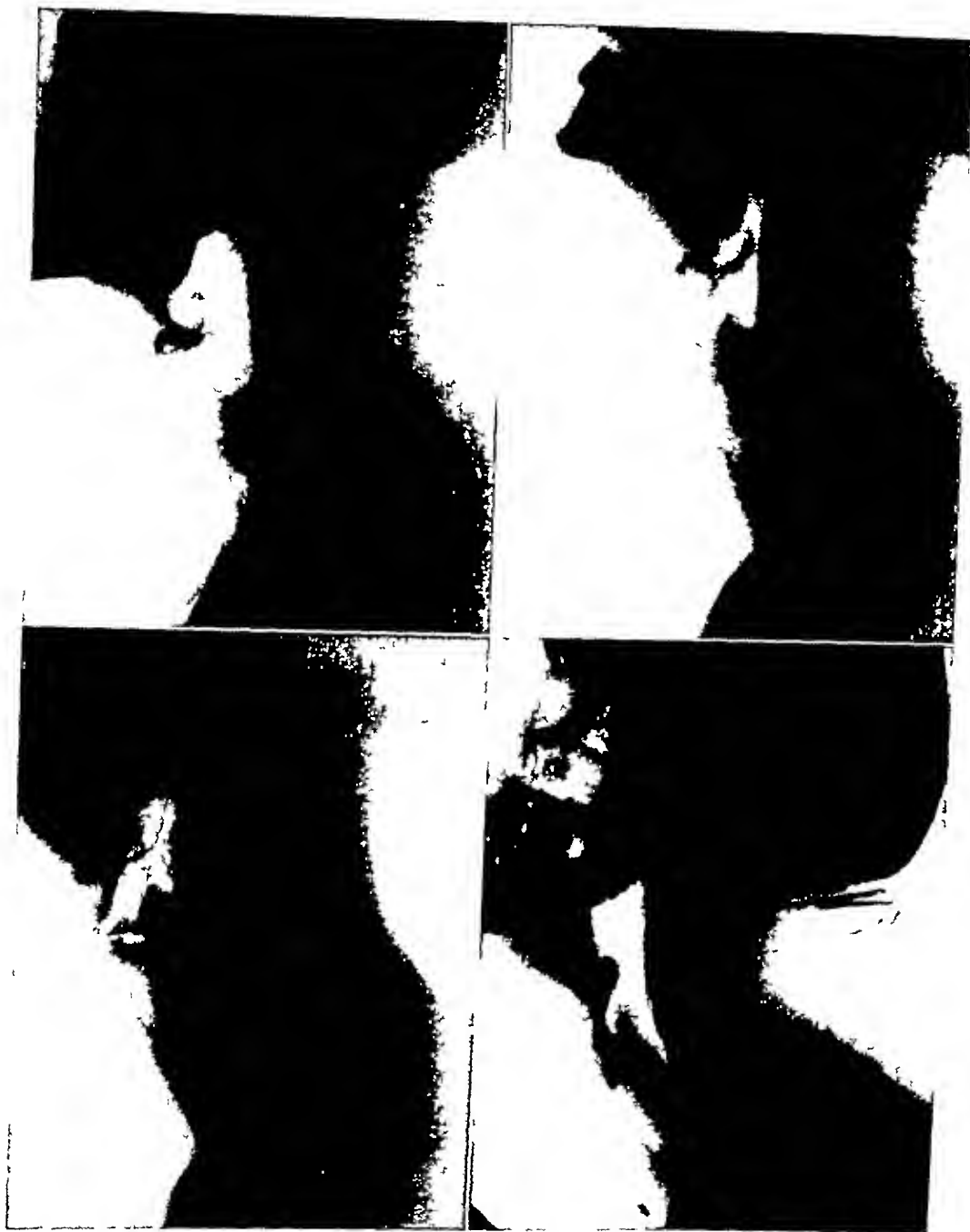


Fig 21 (*upper left*) Lateral view Carcinoma of the larynx Note the poorly outlined larynx The ossified cartilages show marked absorption

Fig 22 A (*upper right*) Lateral view Papilloma of the larynx The outline of the larynx is normal The ventricle is closed No abnormalities are demonstrable

Fig 22 B (*lower left*) Lateral view The same case after the enunciation of the vowel E Note the opening of the ventricle which shows a nodule on the true vocal cord

Fig 23 (*lower right*) Lateral view Laryngeal tuberculosis Note the fragmentation of the ossified laryngeal cartilages Valsalva experiment was used in the examination

Tuberculosis of the Larynx—The cases under our observation have been, as a rule, late We, therefore, cannot discuss of laryngeal tuberculosis that have come



Fig 24 (left) Lateral view. Laryngeal stenosis due to diphtheria. Note the excessive ossification of the laryngeal cartilages. Male, 25 years of age.

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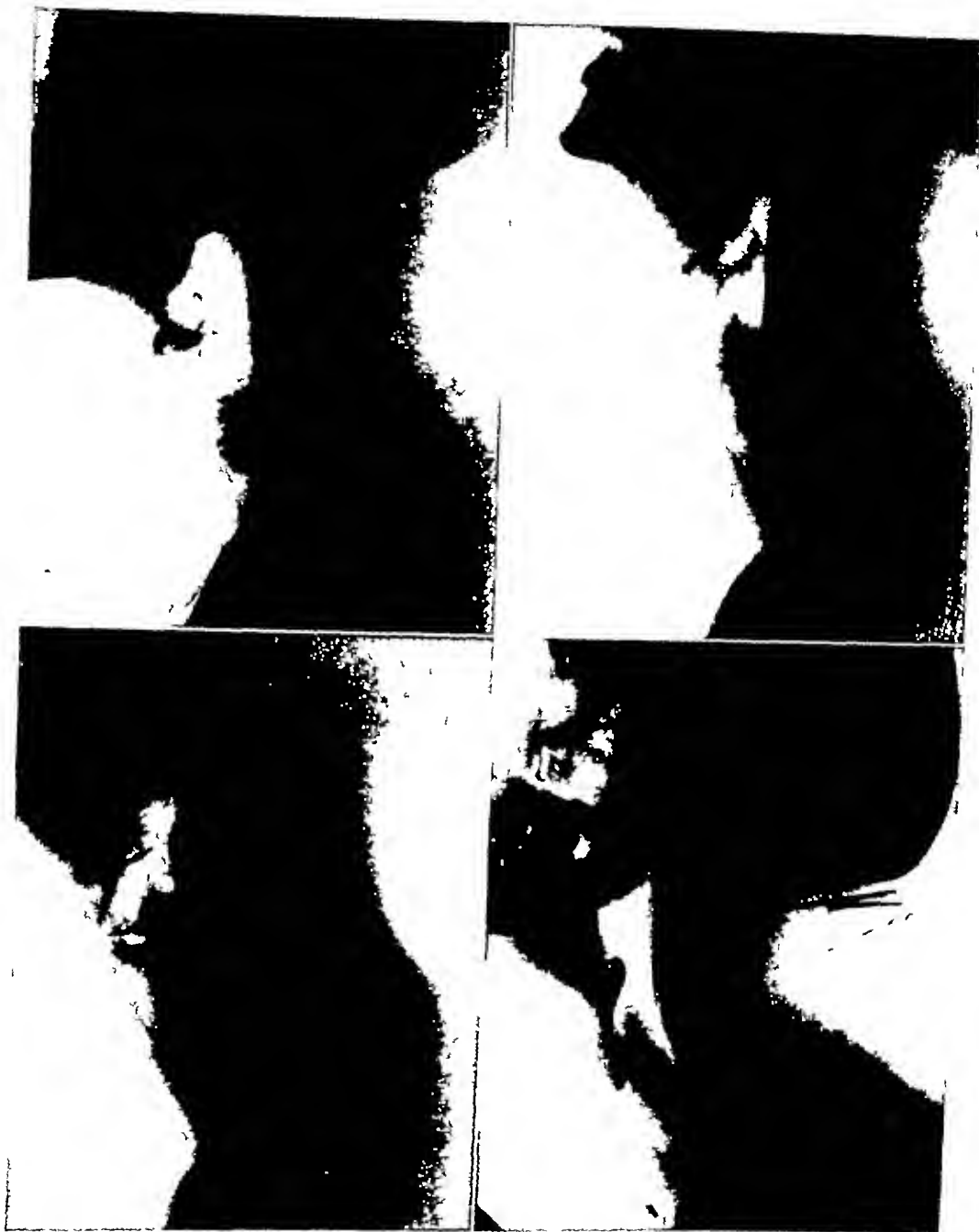


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Emphysema of the Neck—The presence of free air in the tissues of the neck is readily demonstrated by the increased transparency along the fascial planes. Several such cases have come under our observation (Figs 2 and 3), all due to traumatism of one kind or another.

Foreign Bodies—The value of the x-ray in the diagnosis of foreign bodies in the throat is so well recognized and so much has been written on the subject that very little can be added. However, while opaque foreign bodies are readily recognized and require no special material for their recognition, non-opaque foreign bodies can be visualized only by having the patient swallow a fluid mixture of an opaque medium such as bismuth, barium, or one of the iodine preparations in oil. These adhere to the foreign body and outline it.

SUMMARY AND CONCLUSION

An historical review of the roentgenologic literature dealing with the neck is given. The x-ray technic is described. The factors found most applicable in this work are 60 ma, 70-80 kv, 6 feet distance, time, 0.5 to 1 second, in the sitting position. The roentgenograms obtained with these factors show a high degree of fine detail of the soft structures.

The roentgen anatomy and physiology are discussed at length, describing the position, shape, size, relation, and contour of the various structures, during inactivity as well as during respiration, phonation, and deglutition. Much use has been made of the Valsalva experiment, which enables one to obtain more contrast-

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Fig 1

Fig 2

Fig 1 Case 1 Decalcification of humerus, scapula, and ribs caused by metastatic carcinoma
 Fig 2 Case 1 Extensive decalcification of the left femur



Fig 3

Fig 4

Fig 3 Case 2 Fracture of the right femur through a large decalcified area caused by metastatic carcinoma
 Fig 4 Case 2 Extensive calcification of several large areas in the right femur

woman The right breast was normal but there was an ulceration on the left breast two inches in diameter, also, a markedly retracted nipple There was extensive involvement of

CASE REPORTS AND NEW DEVICES

EXTENSIVE BONE METASTASIS IN CARCINOMA OF THE BREAST

By FREDERICK HARVEY, B Sc., M D., F A C S.,
Chicago

Early removal of carcinoma of the breast, followed by deep x-ray therapy and general treatment, helps toward cure and to keep patients alive longer than the employment of only one method. We should avail ourselves of every means to educate the public to seek frequent, thorough examinations, and to obtain medical advice as soon as any abnormal condition or symptom is noted. Since we know that fear is a powerful factor in preventing many persons from consulting a doctor, we do well to explain patiently and explicitly that a policy of putting off the seeking of such examination can result only in letting a tumor, if present, get a head start. If the individual's fears should, happily, prove to be groundless, the sooner they are relieved the better for his general wellbeing.

I report two cases, commenting upon them in conclusion.

Case 1 A B, white female, unmarried, 39 years of age, first came to my attention in 1926 when she entered the North Chicago Hospital to have a carcinoma of the left breast removed. The operation was a radical one, the left breast with adjacent axillary and supraclavicular lymph glands being removed. The wound healed promptly and the patient made an uneventful recovery. She remained in apparent good health until December, 1929, when "shooting pains" extended to the left hip. Dull in character at first, they became progressively more intense. In the latter part of January, 1930, she was unable to support her weight on the left leg.

She entered Grant Hospital on Feb. 7, 1930.

Except for the above-mentioned mastectomy four years previously, the patient's personal, like her family, history was essentially negative.

Physical examination revealed a moderately well nourished individual. The head, neck, heart, lungs, and abdomen were essentially negative. There was marked tenderness over the left hip. The reflexes appeared to be normal.

The laboratory examination of the blood showed red blood cells, 4,360,000, white blood cells, 8,000, hemoglobin, 75 per cent,

with a normal differential count. The blood calcium was 9.8 mg. the urine was negative.

Röntgen Examination—Films of the skull, both femurs, and the pelvis showed some rarefactions and elevations of the calvarium, rarefied areas in the upper third of the left femur, and similar areas in the pelvis. Films made at a later examination showed small areas of rarefaction in the left shoulder and the left scapula.

Clinical Course—There was a gradual, steady loss of vitality. When the patient entered the hospital she was able to sit up in a wheel chair, but within a few months she was confined to bed. Pain developed in both shoulders, and a marked muscular atrophy from disuse occurred. The metastatic growths were controlled to some extent by x-ray therapy but new growths appeared in the left shoulder and along the lower right ribs. A mass was palpable in the abdomen to the left of the epigastrium, and the liver enlarged. The patient complained of distress in the rectum, but no pathology was found on digital examination.

Treatment—The patient received nine complete series of deep x-ray treatments, which checked the growths in some areas. Sedatives were necessary to relieve pain, otherwise she received only a general supportive treatment.

Röntgen examination revealed the following developments of the disease (Feb. 12, 1930) Extensive involvement of the right iliac crest and the right femur, (April 23, 1930) improvement and partial calcareous replacement of rarefied areas in the left femur, upper third, in the skull, the calvarium showed some rarefactions and elevations which were probably extensions of the same process, (April 30, 1930) involvement of the top of the skull, left femur, and crest of the ilium, (April 1, 1931) extensive involvement of the head of the left humerus and scapula and of the first lumbar vertebra, (Dec. 12, 1931) involvement of the top of the cranium, the proximal portion of the left femur, the left humerus, and the scapula.

It is the writer's opinion that the condition was held in check over this period by the intensive course of x-ray treatments given. The patient expired on Dec. 12, 1931. It appears that the treatments helped to control pain, to repress metastatic growths, and to prolong life for one or two years.

Case 2 G B, white female, unmarried, 61 years of age, was seen in April, 1926, following a fall which had injured her left hip. X-ray examination revealed a pathological fracture of the upper part of the femur through a bone cyst about two inches in diameter.

Physical examination showed a thin, anemic

Dr. Harvey met with sudden and tragic death by accident, before he received proof of his paper.—EDITOR



Fig 1

Fig 1 Case 1 Decalcification of humerus, scapula, and ribs caused by metastatic carcinoma



Fig 2

Fig 2 Case 1 Extensive decalcification of the left femur



Fig 3

Fig 3 Case 2 Fracture of the right femur across a large decalcified area, caused by metastatic carcinoma



Fig 4

Fig 4 Case 2 Extensive decalcification of several large areas in the right femur

woman. The right breast was normal, but enlarged in diameter also, a markedly retracted areola was an indication on the left breast two months. There was extensive involvement of

the pectoral and axillary lymph nodes. The patient stated that, three years previously, she had noticed enlargement of the left breast, hardening, and finally ulcerating. A diagnosis of cancer of the left breast was made.

the patient expired on Nov 3, 1926, following amputation at the right thigh.

COMMENT

Both of these patients delayed too long in coming for operation. In Case 1, though an extensive dissection of the lymphatic glands was performed when the left breast was removed, it is evident that the growth had extended beyond the reach of surgery. It is surprising in view of the other metastases that there were no other symptoms than late pain in the left hip, also, the length of life after these metastases appeared, with spreading of deposits to all parts of the body was notable. X-ray treatments, by checking the growth of the early metastatic deposits, with good care and supportive measures, probably kept this patient alive much longer than would otherwise have been the case, thus giving an opportunity for more distant metastases to occur.

In looking over the literature, many cases of extensive metastatic deposits are noted from primary breast carcinoma. Handley has shown that the extension of these deposits is by lymphatic permeation in many instances, but this does not account for all of them. He discusses the work of Dr. Piney, who states that secondary growths in bone occur only in the red marrow, and he could demonstrate no lymphatic vessels in the bone marrow, though there were many in the periosteum. In the marrow, Dr. Piney found the cancer cells growing in the blood channel with no permeation of the periosteal lymphatics. The point of emergence of the tumor on the surface of the bone corresponded to the place of exit of the veins and he thus concluded that the deposits spread in the blood stream.

Dr. Carnett has observed in cases of secondary deposits in the pelvic bones and in the femur that chains of infected glands can often be traced right through the abdomen from the diaphragm, along the aorta and its branches to the groin. He observes that this retrograde permeation of the trunk lymphatics is a more rapid process than permeation of the small lymphatics of the *facial plexus*. Carnett has shown by the x-ray that the humerus is often first attacked in the region of its head. He thinks it probable that the bone is reached by permeation along the tributaries of the infected axillary glands, a process which must occur in a relatively early stage of cancer.

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Fig 5 Case 2 Soft tissue dissected away from right femur at necropsy showing extensive calcified areas

The fracture of the right femur was set and a plaster cast applied. Two months later, x-ray films revealed perfect union, but decalcification was present. A metal splint was applied. On June 19, 1926, the left breast, with adjacent axillary and supraclavicular lymph nodes, was removed by radical operation. The recovery was uneventful, and the incision healed promptly.

X-ray treatments were given over the right thigh, but decalcification continued rapidly and

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Therapy of Mammary Carcinoma Am Jour Roent-
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January, 1928

A SIMPLE METHOD OF PREPARATION OF RADIUM MOLDS

By I MILTON WISE BS MD, *Mobile, Ala*

This method is similar to the one used by Dr Max Cutler in the tumor clinic of Michael Reese Hospital, Chicago, except that I have modified it so that the average radiologist can make these molds without great expense or the use of special equipment

During treatment of lesions on the skin it is both desirable and many times necessary to treat the lesion for several hours at a time, once or twice a day over a period up to ten days. The multiple application and removal of radium in plaques exposes the operator to a great deal of radiation, especially in an office or small clinic where the operator must prepare, apply, and remove the radium himself. This method, which is a modification of Dr Cutler's, reduces stray radiation to a minimum. The radium is applied to exactly the same area at each application. The contiguous structures can be more readily protected. Should further treatment become necessary, as in a case of recurrence, the applicator for that individual is already made to receive the radium element.

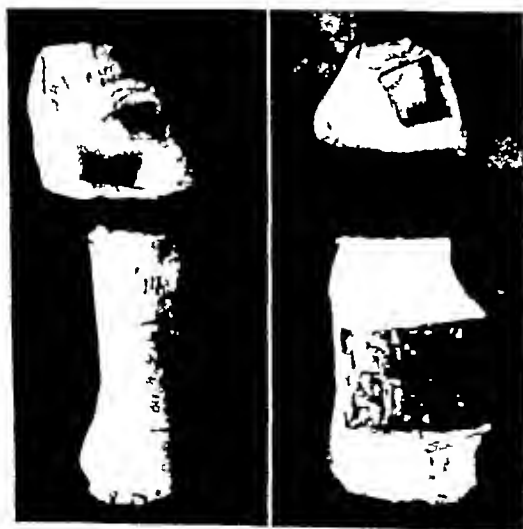


Fig 1 (upper) Cast of lesion on eyelid and the radium mold (Lower) Cast of lesion on leg, and the radium mold



Fig 2 (upper) Cast of lesion on ear and the radium mold (Lower) Cast of lesion on the lobe of the ear and the radium mold

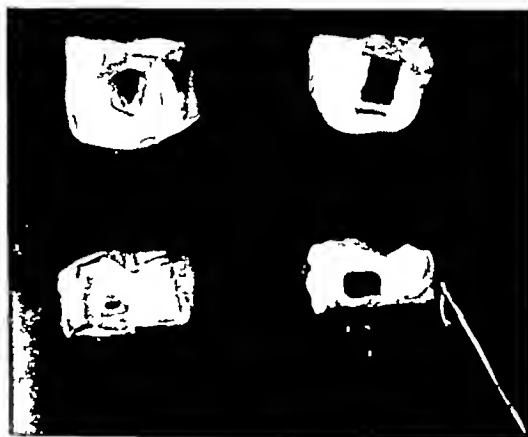


Fig 3 (upper) Cast of the lesion on maxilla and the radium mold (Lower) Cast of the lesion on ala of nose and the radium mold

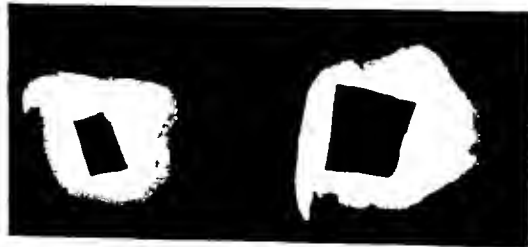


Fig 4 Radiographs of two radium molds to show the relative radiodensity

Finally, it is an advantage to have an accurate reproduction of the condition at the first examination

The method is as follows thin sheets of paraffin or wax are poured to a thickness of about 3 mm and of various sizes, and allowed to harden. With warm water a sheet is then softened until it becomes quite pliable. This sheet is then accurately molded over the lesion, as well as the surrounding tissue, trying to include some landmark that the finished mold will cover so as to insure the same placement of the mold at each application. Usually the lesion can be seen through the partly hardened wax and its border outlined on the outside of the wax. The paraffin is allowed to harden and is then removed, making a negative of the lesion. On the inside of the negative the outline of the lesion is again traced in the wax. Into this wax mold plaster of Paris is poured and allowed to harden, then the wax is removed. A reproduction of the lesion and the surrounding area, or a positive, is obtained, with the lesion outlined on the plaster. A second negative is made by covering the positive with dental wax, base plate or some pliable material that has no filtration value for radium. This becomes the base of the mold and will be in apposition with the skin. The area to be

treated is readily seen and around it is placed a lead box, 1 cm larger than the lesion and of 2 mm thickness of lead. All around this lead box is then filled in with plaster of Paris and into it may be placed paper clips or anything to fasten tape to the mold to hold it in place if so desired. Depending upon the distance desired, the box is filled with wax of no filtration value and the radium placed at its predetermined distance. Should additional filtration be wanted, 1 mm lead can be put in the wax and the radium placed thereon and covered with a little hot wax to hold it in place. Finally the lead box holding the radium is covered with a lead lid, affording further protection to the operator during the application and removal of the mold. This lid may be held in place by the metal clips soldered to the lead box before the plaster is poured or may be held in place by a strip of adhesive tape.

In certain areas, especially about the eye, along the hair line, etc., additional protection may be procured by placing small lead barriers on the base plate before covering it with plaster.

MEASUREMENT OF THE AORTIC DIAMETER BY GEOMETRICAL METHOD

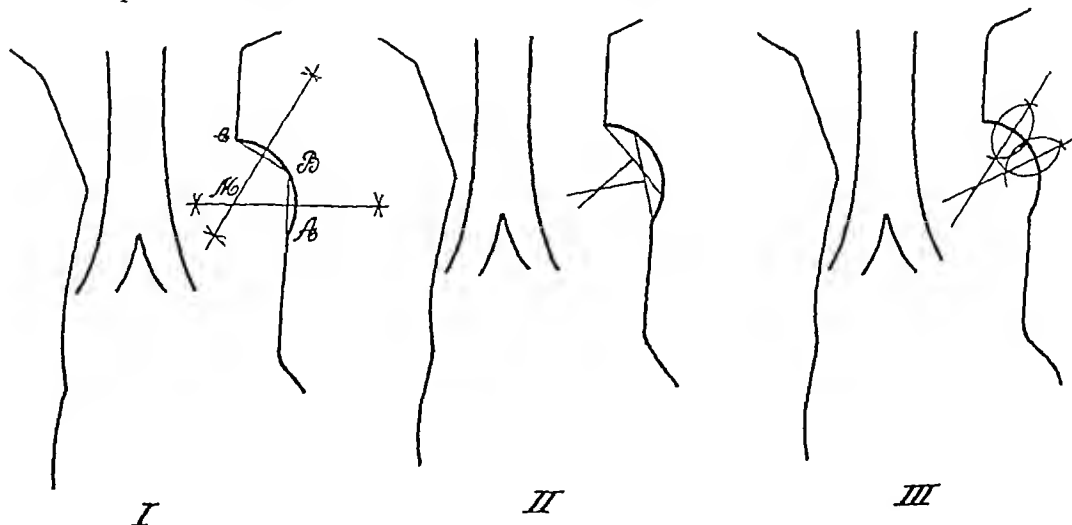
By AGUINALDO LINS, M.D., Recife, Brazil

Director of the X-ray Institute Medical School

Modern technics greatly simplify diagnosis in the exploration of the mediastinal organs,

it was teleradiography that allowed Abreu to create the radiogeometry of the mediastinum that will serve as the basis of this difficult chapter of modern semeiology.

The images are changed in different perspectives because the only condition of visibility of the vascular outlines has its anatomical expression in the pulmonary contiguity. The processes of the mensuration of the aortic



Figs 1 2 and 3

The method is as follows: thin sheets of paraffin or wax are poured to a thickness of about 3 mm and of various sizes, and allowed to harden. With warm water a sheet is then softened until it becomes quite pliable. This sheet is then accurately molded over the lesion, as well as the surrounding tissue, trying to include some landmark that the finished mold will cover so as to insure the same placement of the mold at each application. Usually the lesion can be seen through the partly hardened wax and its border outlined on the outside of the wax. The paraffin is allowed to harden and is then removed, making a negative of the lesion. On the inside of the negative the outline of the lesion is again traced in the wax. Into this wax mold plaster of Paris is poured and allowed to harden, then the wax is removed. A reproduction of the lesion and the surrounding area, or a positive, is obtained, with the lesion outlined on the plaster. A second negative is made by covering the positive with dental wax, base plate or some pliable material that has no filtration value for radium. This becomes the base of the mold and will be in apposition with the skin. The area to be

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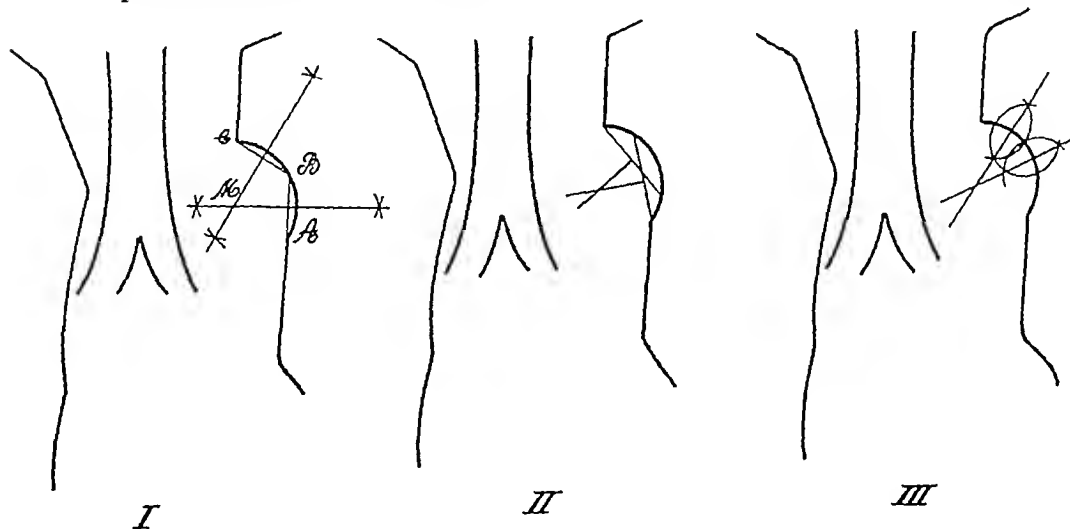
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Figs 1 2 and 3

the use of a block of condensers which are connected as indicated in Figure 1. The tube used is of the familiar 01-A type, the four prongs being shorted. A copper cap is placed

ures associated with lesions of the pituitary gland. This would be especially advantageous in those associated with tumors that did not cause marked focal pituitary symptoms.



Fig 6

Fig 6 Electric light plug-in socket (four minute exposure)

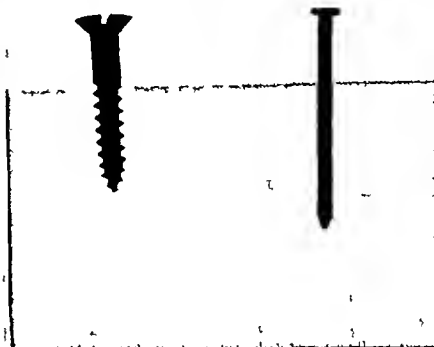


Fig 7

Fig 7 Nail and screw in one and one-half inch pine (one-half minute exposure)

on the tube and connected to the resonator, the prongs being connected to a suitable high resistance. The rotor used to raise the frequency of the current is driven by a $\frac{1}{10}$ hp variable-speed motor and consists of a brass disk four inches in diameter and one-half inch thick in which are placed at one-inch spaces, one-quarter inch mica segments. A rear view of the assembly is shown in Figure 2. Its total weight is 28 pounds.

The machine, when in operation, will produce a beam of x-rays easily detected for a distance of several feet in all directions. With r meter measurements the writers determined the intensity of the rays to be three-fourths of an r unit per minute, at a distance of three feet.

EPILEPSY ASSOCIATED WITH PITUITARY DISTURBANCE: RESPONSE TO X-RAY THERAPY¹

B₃ BERNARD SELIGMAN M.D., *Brooklyn, N. Y.*

From the Out patient Department, Kings County Hospital

Cushing (1) and others have reported epileptic seizures associated with lesions of the pituitary gland. Good results were obtained following the administration of gland substance whether or not the lesions were accompanied by tumors. The following case suggests the employment of x-ray therapy in epileptic seiz-

M. F., born Nov. 9, 1911, was first seen in the Kings County Hospital Out-patient Department on Oct. 21, 1933, at the age of 21. She complained of the presence of soft down on the upper lip and chin for ten years, getting worse in the past five or six years, and stoutness. She was always inclined to be stout. Although she did not complain of fits, she stated that she had had epileptic attacks since the age of ten—from two to four each year. Her mother, who was about the same size and build as the patient, had died of a stroke at the age of 37, two years previously. Her father committed suicide at the age of 40, shortly after the mother's demise. She has three brothers and two sisters alive and well.

Menstruation began at age of 13, is regular every 28 to 30 days, with duration of three or four days, requiring two napkins each day. She has slight pains in the mid-hypogastrium. She states that she goes out with members of the opposite sex and has natural desires, but never has had intercourse. She has occasional coughs with colds, and a rare headache. She had measles as an infant. There is no history of trauma. Her weight has been constant at about 195 pounds for five or six years. She likes all foods and has no excessive thirst except after salty foods. She drinks six or seven glasses of water daily, one or two glasses of milk, one cup of coffee, and two cups of tea—about 2,500 cubic centimeters a day. She urinates six or seven times a day, there is no excessive amount at each voiding.

¹ Read before the New York Endocrinological Society, April 28, 1937.

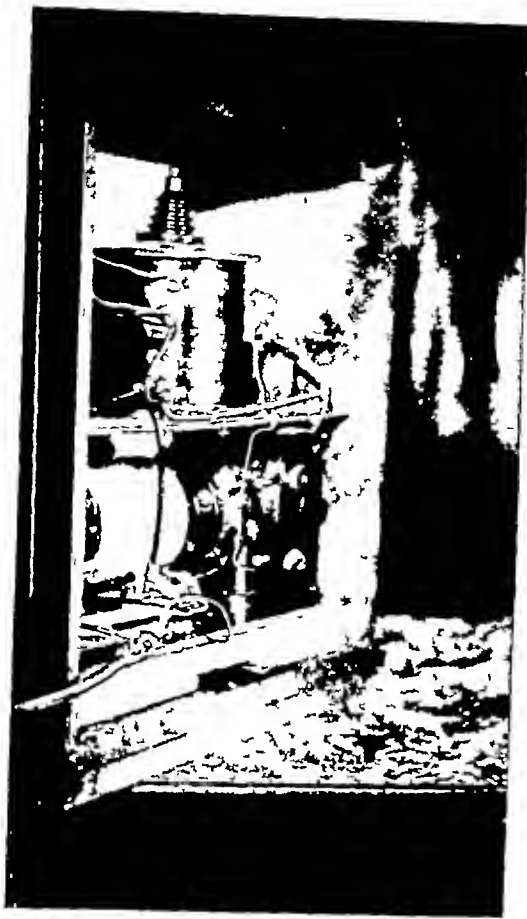


Fig 2 Photograph of rear view of assembly



Fig 3 Elbow and cross-section of young birch tree (one and one half minute exposure)



Fig 4 Glass bottle with bakelite top (two-minute exposure)



Fig 5 Full grown tulip (one minute exposure)

ers (0.16 MF), a "kick coil" of 24-ohm capacity, a resonator for building up the voltage, and an old 01-A radio tube. The schematic plan of the apparatus is given in Figure 1.

The construction of the apparatus is very simple. A "kick coil" consisting of one and one-quarter pound of No. 24 silk covered wire is wound on a bakelite core five eighths inch in diameter and three inches long. The purpose of this coil is to excite the primary circuit of an Oudin resonator which consists of six turns of No. 10 cotton-covered space wound wire which is connected to two ounces of No. 32 double cotton-covered space-wound wire which composes the secondary. The primary of the resonator is further excited by

THE DIVIDED NAVICULAR
OF THE FOOT

By WILLIAM E ANSPACH, M D

and
E BLAKE WRIGHT, M D,
Chicago

The divided or extra navicular, the true tibiale externum of the foot, a well-recognized anatomical entity as early as 1907 (1), has received relatively little attention in recent x-ray literature and is omitted from most charts indicating extra ossicles or anomalies of the

have a mistaken interpretation on roentgenograms when seen for the first time. The following case seems typical

CASE REPORT

M J, female, 25 years of age, a nurse, received an injury to the foot while riding in a taxicab when the car stopped suddenly and the patient slid forward, forcibly flexing her right foot against the back of the front seat. She was taken to the hospital, where it was noticed that the region of the right navicular was



Fig 1 Normal left foot, oblique, antero-posterior, and lateral views. The true tibiale externum is not seen in the lateral view but is nicely set out in the internal oblique

foot. Although it is a rare condition, a brief report would seem in order to call attention to this regular anomaly which is most prone to

prominent. A diagnosis of a sprained ankle was made. Six weeks later a second physician examined the patient and

Present Illness—For the past 12 years, when excited, she has had what she calls "fits" She has a heavy, dopy feeling, with inability to concentrate while talking for a short time, and a nervous feeling "inside the stomach" which occurs about one-half hour before an attack. She then lapses into unconsciousness. She froths from the mouth, snores, yells, and kicks her feet. She is unconscious for a variable period of time, from ten to fifteen minutes on occasion, after which she feels tired and drowsy and then sleeps for several hours. She awakens with a dull headache over the entire head.

Physical Examination—She is 61 inches tall. Span is 60 $\frac{3}{4}$ inches, lower measurement 31 inches. Her weight is 195 pounds. Blood pressure, 118/80, pulse, 96, temperature 97.8. She is short, moderately obese. Her hair is thick and long. Over the upper lip and chin a moderate collection of soft, downy hair is present. The eyebrows are heavy and coarse. The face is large, with a double chin. The breasts are slightly large with a little more fullness of the right breast, a few scattered hairs are present over the areolar region. Her vision is good, eye grounds are negative, the visual fields on gross confrontation test are not limited. The lower teeth over-ride and the last molars are still hidden. The pharynx is injected. The tonsils are small and cryptic. The tongue is slightly coated. The heart and lungs are negative. The abdomen has no tenderness or masses. She has a tendency to a muchal pad and a marked girdle obesity. The integument over the lower thoracic and upper lumbar back is plicated in three large, distinct folds. The thighs and legs are heavy-set, the buttocks large. The hands and feet are small and stubby, especially the feet. Lunulae are present in the nails. On rectal examination, the external genitalia are average, the hymen intact, and the cervix small and infantile. The cranial nerves are intact. Motor and sensory systems are negative and there is no Romberg and no past pointing. All the superficial reflexes are slightly hyperactive. No Hoffman or Babinski reflex was elicited. The Weber test is negative. She has a suggestion of a right ankle clonus. The sella turcica is normal in size, type, and shape and shows no evidence of erosion of the anterior clinoid processes. On the film no increased intracranial pressure is seen. The last molars are unerupted. Fluoroscopy of the wrists shows the epiphyses of radius and ulna fused. The distal phalanges are delicate.

Sugar tolerance curve

103 milligrams per cent on a fasting stomach
110 milligrams per cent one hour later
118 milligrams per cent two hours later
118 milligrams per cent three hours later

Blood cholesterol, 162 milligrams per cent

Forty c.c. of whole blood two weeks after menstruation shows one normal menstrual cycle in a mouse. The basal metabolic rate was plus 19 per cent.

She was placed on a "degenerative obesity diet" of Langstroth (2) and given $\frac{1}{8}$ grain of thyroid *tid* for one month. It was discontinued because her pulse rose slightly to 100. She lost 45 pounds, dropping her weight to 150.

On May 18, 1934, she was given 600 r to the right pituitary field² and on May 19, 1934, a similar dosage to the left pituitary field through a small portal. This was given with the thought that she might have a basophilic lesion of the pituitary gland accounting for the hirsuties. She was asked to report back in six months but was not seen until February, 1937, when she stated that she had an attack in January, 1936, and another in February, 1936. In other words, she had gone for a period of 20 months without any attacks whatsoever, although she previously had had from two to four attacks each year. There was an interval of two years since her previous attack. She was not cognizant of the fact that this treatment was given for her epilepsy but was under the impression that it was to help her hirsutism and hence did not report for further x-ray treatments. Her hirsutism is still present although improved by electrolysis therapy. She has had no changes in her menses since the therapy and feels much better mentally. She has grown about one-half inch.

SUMMARY

Female, 21, with girdle obesity, increased glucose tolerance, moderate polydipsia and polyuria, hypotension, negative sella turcica, or other evidence of focal pituitary symptoms or signs, diminished female sex hormone in blood, normal blood cholesterol. She had, however, a slightly elevated basal metabolic rate and tachycardia with a moderate hirsutism of the soft, lanugo type. After she was given two doses of 600 r to the pituitary, no seizures occurred, for a period of two years. The clinical picture shows significant factors indicative of a hypopituitary condition with no evidence of a hypophyseal tumor. The course shows presumptive evidence of an amelioration of the "spells" by the use of the roentgen therapy. The signs and symptoms may have been due to a small chromophobe adenoma of the pituitary.

²X-ray Therapy Department, Asa B. Friedman, M.D.

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condition is infrequently met with, its similarity to a fracture should cause it to be included on working charts. It is the largest regular anomaly of the tarsals and because of having a closer relationship to the regular bones it is more prone to have a mistaken interpretation than the more common extra ossicle, also called the *tibiale externum*, which is located in the tendon and is usually at some distance from the regular navicular. The *true tibiale externum*, the name given to the mesial portion of the divided navicular, is located at the insertion of the tendon of the *tibialis posticus* muscle and is fixed in position to its component, which appears to be the regularly formed navicular. The smaller sesamoid of the same name is located out in the tendon of the same *tibialis posticus* muscle. Because of the prominence on the surface of the foot of the *true tibiale externum*, it would seem to be more exposed to injury than the smaller anomaly.

When roentgenograms of the divided scaphoid are seen for the first time, immediately following an accident, the *true tibiale externum* should be thought of, but a mistaken diagnosis of a fracture is most likely to be made. Even later, if there has been a painful injury, the same mistake may logically occur. Extremely late, the smooth contour and texture suggests the absence of a fracture and a mistake in the diagnosis should not be repeated. Although linear fractures of the navicular of the foot are rare compared with those of the hand, the fragments at first are sharply defined and are most often seen as counterparts, frequently fitting perfectly together. Later, one of the fragments is almost sure to change in density because of a disturbed circulation, and appear relatively more dense. The contacting surface of the other fragment at the same time tends to become sclerotic. Sometimes cystic changes or additional fractures become evident as time goes on. The absence of all of these changes favors an anomaly, as does the presence of mild or absent symptoms. The diagnosis of an anomaly is, of course, supported when the same change is found in the uninjured foot. While it seems that this anomaly is most likely to be bilateral, too few cases have been recorded up to the present time to warrant one's being sure on this point.

The changes that normally occur in the ossification centers of the navicular during the active period of growth are often erroneously thought to be undergoing necrosis (aseptic necrosis) and are frequently labeled Köhler's disease, even though normal density is present. This occurs because every so often there is a cluster of densities in place of a solitary density indicating the ossification center of the navicular. Consequently in early childhood



Fig 3 Five scaphoids showing the varying development of the *true tibiale externum*. (Plate XXVII, Fig 60 from *Variations of the Bones of the Hands and Feet*, by Thomas Dwight.)

genograms made of the foot from different angles, made a diagnosis of a fractured navicular and had a cast applied. The patient suffered little and the cast was removed at the end of two weeks. A few days later the patient re-

pearance of two distinct bones. An anomalous divided navicular was thought to exist, and an examination of the normal left foot showed identical changes (Fig 1). Through the kindness of the patient and the courtesy of the



Fig 2 Injured right foot (same views as in Figure 1). Note the exact similarity to the uninjured left foot, indicating the presence of a divided navicular and ruling against a fracture.

ported to one of us (E. B. W.) for a check-up examination. The other (W. E. A.) was requested to make a roentgenographic examination to note progress. Films of the right foot made at different angles showed the navicular divided into two apparently isolated portions (Fig 2). Each had normal appearing borders, but at the point of contact with each other the surfaces were slightly flattened. The texture of each segment appeared normal and while there did not seem to be a well-formed joint space between them, they presented the ap-

pearance of two distinct bones. While the divided navicular of the foot has been occasionally mentioned in the literature, and this condition was beautifully illustrated by Dwight in 1907 (Fig 3), it has been given little attention since, and demonstrations on roentgenograms have been rare. Although this

COMMENT

While the divided navicular of the foot has been occasionally mentioned in the literature, and this condition was beautifully illustrated by Dwight in 1907 (Fig 3), it has been given little attention since, and demonstrations on roentgenograms have been rare. Although this

condition is infrequently met with, its similarity to a fracture should cause it to be included on working charts. It is the largest regular anomaly of the tarsals and because of having a closer relationship to the regular bones it is more prone to have a mistaken interpretation than the more common extra ossicle, also called the *tibiale externum*, which is located in the tendon and is usually at some distance from the regular navicular. The *true tibiale externum*, the name given to the mesial portion of the divided navicular, is located at the insertion of the tendon of the *tibialis posticus* muscle and is fixed in position to its component, which appears to be the regularly formed navicular. The smaller sesamoid of the same name is located out in the tendon of the same *tibialis posticus* muscle. Because of the prominence on the surface of the foot of the *true tibiale externum*, it would seem to be more exposed to injury than the smaller anomaly.

When roentgenograms of the divided scaphoid are seen for the first time, immediately following an accident, the *true tibiale externum* should be thought of, but a mistaken diagnosis of a fracture is most likely to be made. Even later, if there has been a painful injury, the same mistake may logically occur. Extremely late, the smooth contour and texture suggests the absence of a fracture and a mistake in the diagnosis should not be repeated. Although linear fractures of the navicular of the foot are rare compared with those of the hand, the fragments at first are sharply defined and are most often seen as counterparts, frequently fitting perfectly together. Later, one of the fragments is almost sure to change in density because of a disturbed circulation, and appear relatively more dense. The contacting surface of the other fragment at the same time tends to become sclerotic. Sometimes cystic changes or additional fractures become evident as time goes on. The absence of all of these changes favors an anomaly, as does the presence of mild or absent symptoms. The diagnosis of an anomaly is, of course, supported when the same change is found in the uninjured foot. While it seems that this anomaly is most likely to be bilateral, too few cases have been recorded up to the present time to warrant one's being sure on this point.

The changes that normally occur in the ossification centers of the navicular during the active period of growth are often erroneously thought to be undergoing necrosis (aseptic necrosis) and are frequently labeled Köhler's disease, even though normal density is present. This occurs because every so often there is a cluster of densities in place of a solitary density indicating the ossification center of the navicular. Consequently in early childhood



Fig 3 Five scaphoids showing the varying development of the *true tibiale externum*. (Plate XXVII, Fig 60 from *Variations of the Bones of the Hands and Feet*, by Thomas Dwight.)

the scaphoid may vary considerably in appearance, but as a rule, later, the usual picture is seen. Clinically, there may be no evidence of trouble at any time. While the merging several small densities into one most often occurs, infrequently one segment makes an independent development as an extra ossicle. The *true tibiale externum* seems to be formed in this way. It really represents the isolated tuberosity of the navicular and has an origin quite different from the small sesamoid bearing the same name. The latter is the one commonly seen

and usually meant when the name "tibiale externum" is used. The *true tibiale externum* shares the duties of the regular one-piece navicular and, therefore, is better described as an *extra navicular*, or, because of the function performed by both parts, the *divided navicular*.

1150 N. State St.

REFERENCE

- (1) DWIGHT, THOMAS. Variations of the Bones of the Hands and Feet. Lippincott, 1907.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

CALENDAR

Meetings Falling Between the Dates of December 15 and January 31

January 28, 29 Annual meeting of Conference of Eastern Radiologists in Philadelphia

Editor's Note—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section

CALIFORNIA

California Medical Association, Section on Radiology—Chairman, John D Lawson, M D, 1306 California State Bldg, Sacramento, Secretary, Karl M Bonoff, M D, 1930 Wilshire Blvd, Los Angeles Meets annually with California Medical Association

Los Angeles County Medical Association, Radiological Section—President, D R McColl, M D, Vice president, John F Chapman, M D, Secretary, E N Liljedahl, M D, Treasurer, Henry Snure, M D Meets every second Wednesday of month at County Society Building

Pacific Roentgen Club—Chairman, Raymond G Taylor, M D, 1212 Shatto St, Los Angeles, Secretary, L Henry Garland, M D, 450 Sutter St, San Francisco

COLORADO

Denver Radiological Club—President, W Walter Wasson, M D, 246 Metropolitan Bldg, Vice president, Ernst A Schmidt, M D, Colorado General Hospital, Secretary, Nathan B Newcomer, M D, 306 Republic Bldg, Treasurer, Leonard G Crosby M D 366 Metropolitan Bldg Meets third Tuesday of each month at homes of members

CONNECTICUT

Connecticut State Medical Society, Section on Radiology—Chairman Kenneth K Kinney, M D, 29 North Street, Willimantic, Vice chairman, Francis M Dunn, M D 100 State Street, New London, Secretary Treasurer, Max Chman, M D, 242 Trumbull St, Hartford Meetings twice annually in May and September

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society

FLORIDA

Florida State Radiological Society—President, Gerald Raap, M D 168 S E First St Miami, Vice president, H O Brown, M D, 404 First Nat'l Bank Bldg Tampa, Secretary Treasurer, H B McEuen, M D, 126 W Adams St Jacksonville

ILLINOIS

Chicago Roentgen Society—President, David S Beilin, M D, 411 Garfield Ave, Vice president Chester J

Challenger, M D, 3117 Logan Blvd., Secretary-Treasurer, Roe J Maier, M D, 7752 Halsted St. Meets second Thursday of each month, September to May, except December

Illinois Radiological Society—President, Ivan Brouse, M D, 316 W State, Jacksonville, Vice-president, Cesar Gianturco, M D, Carle Hospital Clinic, Urbana, Secretary-Treasurer, Edmund P Halley, M D, 968 Citizens Bldg, Decatur Meetings quarterly by announcement.

Illinois State Medical Society, Section of Radiology—President, Roswell T Pettit, M D, 728 Columbus St., Ottawa, Secretary, Ralph G Willy, M D, 1138 N Leavitt St, Chicago

INDIANA

Indiana Roentgen Society—President, J N Collins, M D, 23 E Ohio St, Indianapolis President-elect, Stanley Clark, M D, 108 N Main St, South Bend, Vice-president, Juan Rodriguez, M D, 2903 Fairfield Ave Fort Wayne, Secretary-Treasurer, Clifford C Taylor, M D, 23 E Ohio St, Indianapolis Annual meeting in May

IOWA

The Iowa X-ray Club—Holds luncheon and business meeting during annual session of Iowa State Medical Society

MAINE

See New England Roentgen Ray Society

MARYLAND

Baltimore City Medical Society, Radiological Section—Chairman, Marcus Ostro, M D, 1810 Eutaw Place, Secretary, H E Wright, M D, 101 W Read St Meetings second Tuesday of each month

MASSACHUSETTS

See New England Roentgen Ray Society

MICHIGAN

Detroit X-ray and Radium Society—President, C C Birkelo, M D, Herman Keifer Hospital, Vice president, E W Hall, M D, 10 Peterboro St Secretary-Treasurer, E R Witwer, M D, Harper Hospital Meetings first Thursday of each month from October to May inclusive, at Wayne County Medical Society Bldg

Michigan Association of Roentgenologists—President, J C Kenning, M D, 1536 David Whitney Bldg, Detroit, Vice president, A W Chasc, M D, 133 Toledo St, Adrian, Secretary-Treasurer C S Davenport, M D, 609 Carey St, Lansing

MINNESOTA

Minnesota Radiological Society—President, Walter H Ude M D, 78 S 9th St, Minneapolis, Vice president Leo G Rigler M D, University Hospitals, Min-

neapolis, *Secretary-Treasurer*, Harry Weber, M D, 102 Second Ave., S W, Rochester Meetings quarterly

MISSOURI

The Kansas City Radiological Society—*President*, L G Allen, M D, 907 N 7th St, Kansas City Mo, *Secretary*, Ira H Lockwood, M D, 306 E 12th St, Kansas City, Mo Meetings last Thursday of each month

The St Louis Society of Radiologists—*President*, Joseph C Peden, M D, 634 N Grand Blvd, *Secretary*, W K Mueller, M D, 607 N Grand Blvd Meetings fourth Wednesday of each month

NEBRASKA

Nebraska Radiological Society—*President*, E W Rowe, M D, 128 N 13th St, Lincoln, *Secretary*, D Arnold Dowell, M D, 117 S 17th St, Omaha Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island) *President*, Frank E Wheatley, M D, 520 Beacon St, Boston, *Secretary*, E C Vogt, M D, 300 Longwood Ave., Boston Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library

NEW HAMPSHIRE

See New England Roentgen Ray Society

NEW JERSEY

Radiological Society of New Jersey—*President*, J D Tidaback, M D, 382 Springfield, Summit, *Vice-president*, Milton Friedman, M D, Newark Beth Israel Hospital Newark, *Secretary*, P S Avery, M D, 546 Central Ave., Bound Brook Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Brooklyn Roentgen Society—*President*, Albert Voltz, M D, 115-120 Myrtle Avenue, Richmond Hill, *Vice-president*, A L L Bell, M D, Long Island College Hospital, Henry, Pacific, and Amity Sts, Brooklyn, *Secretary-Treasurer*, E Mendelson, M D, 132 Parkside Ave, Brooklyn Meetings first Tuesday in each month at place designated by president

Buffalo Radiological Society—*President* John Barnes, M D, 875 Lafayette Ave., *Vice president* W L Mattick, M D, 290 Highland Drive, *Secretary-Treasurer*, J S Gian-Franceschi, M D 610 Niagara Street. Meetings second Monday evening each month

Central New York Roentgen ray Society—*President*, W E Achilles M D, 60 Seneca St. Geneva, *Vice president* M T Powers M D, 250 Genesee St., Utica, *Secretary-Treasurer*, Carlton F Potter M D, 425 Waverly Ave, Syracuse. Meetings held in

January, May and October as called by Executive Committee.

Long Island Radiological Society—*President*, David E Ehrlich, M D, 27 W 86th St, New York City, *Vice president* H Kouransky, M D, 43-37 47th St., Long Island City, *Secretary*, S Schenck, M D, 115 Eastern Parkway, Brooklyn, *Treasurer*, Moses Goodman, M D, 45-01 Skillman Ave., Long Island City Meetings third Thursday evening each month at Kings County Medical Bldg

New York Roentgen Society—*President*, E F Merrill M D, 30 W 59th St., New York City, *Vice president* I W Lewis, M D, *Secretary*, H K. Taylor M D, 667 Madison Ave New York City, *Treasurer*, R D Duckworth, M D, 170 Maple Ave White Plains Meetings third Monday evening each month at Academy of Medicine.

Rochester Roentgen ray Society—*Chairman*, Joseph H Green M D, 277 Alexander St, *Secretary*, S C Davidson, M D 277 Alexander St Meetings at convenience of committee

Society of Radiological Economics of New York—*President*, Albert L Voltz, M D, 115-120 Myrtle Ave, Richmond Hill, *Vice president*, M M Pomeranz, M D, 911 Park Ave New York City, *Secretary*, W F Francis, M D, *Treasurer* Theodore West M D United Hospital, Port Chester Meetings first Monday evening each month at McAlpin Hotel

NORTH CAROLINA

Radiological Society of North Carolina—*President*, Robert P Noble M D, 127 W Hargett St. Raleigh, *Vice president* A L Daughtridge, M D, 144 Coast Line St Rocky Mount, *Secretary-Treasurer*, Major I Fleming M D 404 Falls Road, Rocky Mount Meetings with State meeting in May, and meeting in October

OHIO

Cleveland Radiological Society—*President* North W Shetter, M D Lakewood City Hospital, Lakewood, *Vice president* John Heberding, M D, St Elizabeth's Hospital Youngstown, *Secretary Treasurer*, Harry Hauser, M D, Cleveland City Hospital, Cleveland Meetings at 6 30 P.M. at Cleveland Chamber of Commerce Club on fourth Monday of each month from October to April inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists)—*President* George Benzing, M D St Elizabeth Hospital Covington Ky, *Secretary-Treasurer*, Justin E McCarthy M D, 707 Race St, Cincinnati, Ohio Meetings held third Tuesday of each month

PENNSYLVANIA

Pennsylvania Radiological Society—*President* Sydney J Hawley, M D, Geisinger Memorial Hospital

Danville, *First Vice president*, William J McGregor, M D, 744 Franklin Ave, Wilkinsburg, *Second Vice-president*, Oscar M Weaver, M D, 12 S Main St., Lewistown, *Secretary-Treasurer*, Lloyd E Wurster, M D, 416 Pine St, Williamsport, *President elect*, Charles S Caldwell, M D, 520 S Aiken Ave, Pittsburgh Annual meeting May 1938 Exact date and place to be decided

Philadelphia Roentgen Ray Society—*President*, Thomas P Laughery, M D, Germantown Hospital, *Vice-president*, Elwood E Downs, M D, Jeans Hospital, Fox Chase, *Secretary*, Barton H Young, M D, Temple University Hospital, *Treasurer*, R Manges Smith M D, Jefferson Hospital Meetings first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S 22nd St, 8 15 P M

The Pittsburgh Roentgen Society—*President*, F L Schumacher, M D, Jenkins Arcade, *Secretary*, H N Mawhinney, M D Mercy Hospital Two Fall and two Spring meetings at time and place designated by president

RHODE ISLAND

See New England Roentgen Ray Society

SOUTH CAROLINA

South Carolina X ray Society—*President*, Robert B Taft, M D, 105 Rutledge Ave, Charleston, *Secretary*, Hillyer Rudisill, M D, Roper Hos-

pital, Charleston Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

Memphis Roentgen Club—Chairmanship rotates monthly in alphabetical order Meetings second Tuesday of each month at University Center

Tennessee State Radiological Society—*President*, H S Shoulders, M D, 246 Doctors Bldg, Nashville, *Vice-president*, S S Marchbanks, M D, 508 Medical Arts Bldg, Chattanooga, *Secretary Treasurer* Franklin B Bogart, M D, 311 Medical Arts Bldg, Chattanooga Meeting annually with State Medical Society in April

VERMONT

See New England Roentgen Ray Society

VIRGINIA

Radiological Society of Virginia—*President*, Fred M Hodges, M D, 100 W Franklin St, Richmond, *Vice-president*, L F Magruder M D, Raleigh and College Aves, Norfolk, *Secretary*, V W Archer, M D, University of Virginia Hospital Charlottesville.

WASHINGTON

Washington State Radiological Society—*President*, H E Nichols M D, Stimson Bldg, Seattle, *Secretary*, T T Dawson, M D, Fourth and Pike Bldg, Seattle Meetings fourth Monday of each month at College Club

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

THE PRACTICE OF RADIOLOGY IN THE HOSPITAL

A DISCUSSION OF THE PROPOSED SEPARATION OF THE X-RAY EXAMINATION INTO "TECHNICAL" AND "PROFESSIONAL" PORTIONS

Prepared by the Executive Committee of the Pacific Roentgen Club

Genesis—The immediate cause for the consideration of this problem is the desire on the part of hospitals to include x-ray and clinical laboratory work along with standard bed care in hospitalization insurance plans. The inclusion of the services of the radiologist in such plans of insurance places the hospital in the position of attempting to practise medicine. Desiring to circumvent such illegal practice it occurred to some hospital superintendents to separate the x-ray examination, and thereby the x-ray charges, into two parts, a so-called technical part and a professional part. They proposed to furnish the first along with and as a part of hospitalization, and to furnish the second in a haphazard manner by "permitting" the roentgenologist to interpret the films (and charge therefor) when and if called in consultation. The root of the problem, therefore, lies in the peculiar relationship between hospitals and roentgenologists.

Problem of Dual Interest—It is perfectly obvious that there are two interests involved in the practice of roentgenology in a hospital. The hospital has an investment in equipment and space, and it sometimes provides technical and stenographic services and supplies to the department. It thus has a definite interest in the money to be collected. On the other hand, the physician practising roentgenology practises his specialty with the use of the equipment and personnel, and, having to earn his living thereby, also has an interest in the money collected.

Division of Dual Interest—It would seem logical on superficial examination of the subject to divide the fee for x-ray service into two parts, one to cover overhead and one to cover professional service. The difficult problem is where to divide the examination and the fee.

Some hospitals claim that it is a hospital procedure up to the point of interpretation, that they can produce roentgenograms without any but lay help, others, having tried this plan, realize that the production of adequate roentgenograms requires more than lay help, that it is truly a professional or professional technical procedure (just as operative surgery, regarded by some as a technical procedure, is really a professional technical procedure). The following arguments are submitted to show that the hospital actually has no interest beyond the provision of proper space and equipment, and, in some instances, materials, and personnel, and *actually should not be allowed to attempt the production of roentgenograms without the services of the roentgenologist*. Fluoroscopic examinations and roentgen diagnosis are assumed, without argument, to be medical procedures.

HOSPITALS SHOULD NOT PRODUCE ROENTGENOGRAMS

Firstly, because the technical work of producing a roentgenogram is a medical procedure.

(a) It involves the penetration of the human body by a very dangerous physical agent. In this sense, it is as much a medical procedure as the administration of drugs intravenously, subcutaneously, or by any way other than the patient's own conscious act.

(b) A knowledge of medical anatomy and at least a working knowledge of gross pathology is necessary to properly direct the angles of projection in order to demonstrate the various parts involved, and in some cases a knowledge of diseases is required really to know what is to be shown.

(c) Medical judgment is required to decide the adequacy or inadequacy of the films obtained.

(d) The making of films is part of the examination of ill, often seriously ill, persons, and thus should be under the immediate direction of a physician (roentgenologist)

The statement that the technical side of roentgenography is not a medical procedure originates most frequently from those who are not in close contact with x-ray offices or hospital departments wherein they would see readily how often the roentgenologist is consulted by the technical staff on various cases. When a roentgenologist makes the statement he always assumes medical supervision. Any act that requires medical supervision is *per se* a professional act.

Secondly, because it is not possible to entrust the entire examination to a lay technician, even though we grant that some lay technicians can do a great deal of the work adequately. Credit should be given to roentgenologists that they have been able to train so well relatively inexpensive assistants and thereby lower the cost of radiographic work.

(a) Just as many surgeons' nurses take care of many of the routine surgical dressings and in many of the hospitals assist at operations, but are not allowed to do these things except under supervision, so x-ray technicians may do many technical procedures, but they should be under the supervision and direct control of a physician responsible for these procedures.

(b) Any case deviating from the routine requires a medical opinion from a roentgenologist as to whether more studies are needed to elucidate the problem. The value of most roentgenologic departments varies directly with the amount of time and supervision given to it by the roentgenologists.

(c) Such a procedure artificially separates the method of examination from the interpretation of results. This sometimes causes serious misunderstandings and mistakes. The proper balance between radiographic and fluoroscopic work can be maintained only when the radiologist is present to make the decision.

(d) Lay controlled departments have proved unsatisfactory.

Thirdly, because the analogy between surgery and x-ray which has been advanced very often shows the true situation. In surgery, the hospital provides operating rooms, instruments, and nurses but does not attempt to use these instruments. In some medical departments, the hospital provides blood-pressure apparatus, stethoscopes, and ophthalmoscopes,

but does not attempt to use them. In the x-ray department, by comparison, the hospital may provide x-ray apparatus, rooms, technicians, and clerical assistants but should not use them without medical supervision and, therefore, should not attempt to produce roentgenograms.

Problem of Specialization—Granting all of the above, it could be argued that the attending physician should be able to direct the x-ray examination. The fact remains however, that, with few exceptions, he is not able to do so. If he were so able, roentgenology as a specialty would not have developed. The average conscientious physician or surgeon will admit his inability to direct the entire x-ray examination. X-ray technic in theory and in practice is so specialized that it is not possible to train all physicians in it. Good hospitals do not allow any but qualified surgeons to operate in the surgery; no more should they allow any but qualified roentgenologists to operate in the department of roentgenology.

It might be argued that many of the simpler procedures could be done by a lay technical staff directed by the general practitioner. The fallacy of this is well shown by the average run of films from hospitals in small towns where this is done by necessity.

It is self-evident that if men of any talent are to be attracted to the field of roentgenology, so that it can continue to advance, both for the improvement of diagnostic medical practice and for the general good of humanity, there must be sufficient rewards to make it attractive. The surgeon is able to do many minor things without charge because he can collect large fees for his technical (operative) work. The roentgenologist is not able to collect any such large fees and, therefore, must make small amounts from each examination. If the minor examinations were to be removed from his category, he would, in order to exist, have to charge more for the major examinations.

One practical difficulty in dividing the fee for x-ray work is that with charges of such small denomination, the patients would object to paying two fees. Presuming that they paid the hospital fees first, they would assume that they had paid for their roentgenologic examination and would balk at paying an interpretation or diagnostic charge when this was submitted by the doctor. Neither the lay public nor the medical profession have been educated to the two-fee idea.

Conclusions—The x-ray examination is, and always has been, fundamentally a medical procedure. Roentgenology as a science is still in its infancy. The medical profession as a whole should not stand by idly while hospitals or short-sighted lay interests try to take over this phase of medical practice under the guise of calling it a technical procedure. The actual operation in surgery is in the same sense a technical procedure, auscultation and percussion are technical procedures, cystoscopic examinations are technical procedures. If all of these are separated from physicians, how will medicine, including radiology, advance or even maintain its present position? X-ray technicians must be trained by physicians. Who will train them when the specialty of radiology no longer exists? This whole proposal of artificial division is a retrograde step.

Everyone agrees that the hospital should have a great interest in its equipment, in its space, and in its personnel, but here the interest ceases. They can charge for the materials, interest on investment, salaries, and rental but not for the production of roentgenograms. If the hospital is able to hold out as part of the bait for its insurance policy only the strictly hospital portion of the x-ray examination and if the patient has to pay the recognized roentgenologist for the rest, the bait will not be big enough. There seem to be better ways of protecting the hospital's interest than the division of the medical x-ray examination into two artificial portions. One of these is the maintenance of the quality and soundness of the medical care practised in the hospital, the other is the recognition of the rights of the medical profession, who in the final analysis actually make the hospital what it is—a living institution for the care of the sick *in the hospital*.

COMMUNICATIONS

THE AMERICAN BOARD OF RADIOLOGY

At the annual meeting of the American Board of Radiology, held in Atlantic City, June, 1937, the following requirements and recommendations as to professional training were adopted.

The purpose of this report is to outline the method or methods which are recommended for graduate training in radiology. The spe-

cific requirements to which the Board of Radiology is committed at present are

- (A) Professional Education¹
 - (1) Graduation from a medical school of the United States or Canada, recognized by the Council on Medical Education and Hospitals of the American Medical Association
 - (2) Completion of an internship of not less than one year in a hospital approved by the same Council
 - (3) Three years' training in radiology or sufficient experience in lieu thereof
- (B) Special Training (to be effective after Jan 1, 1940)
 - (1) A period of study after the internship of not less than three years in an institution or radiological department recognized by the same Council and the Board of Radiology as competent to provide a satisfactory training in the field of radiology, or equivalent training acceptable to the Board
 - (2) This period of specialized preparation shall include
 - (a) Graduate training in pathologic anatomy, radiophysics, and radiobiology,
 - (b) An active experience of not less than twenty-four months in a radiological department recognized by the Board and the Council as capable of providing satisfactory training,
 - (c) Examination in the basic sciences of radiology as well as in the clinical aspects thereof

In the final analysis the most important element in adequate radiologic training is not the school, nor the content or arrangement of the course, but the instructor. He should be endowed with the ability not only to teach but also to inspire, to stimulate, and to impart by example those principles and that attitude of mind conducive to the best practice of radiology. Similarly, the future of radiology depends not on the type or formula of the course nor on the accuracy or thoroughness of

¹ In case of an applicant whose training has been received outside of the United States and Canada the credentials must be satisfactory to the Advisory Board for Medical Specialties

the instruction, but on the qualification of the candidate for training, and careful selection of candidates is the very foundation of successful education, for an excellent course cannot make a proficient radiologist out of poor material but an apt student may acquire competence despite limitations of opportunity. With this factor in mind, the Board suggests that the proper approach to graduate training in radiology is through a hospital or institutional residency and that the candidate be selected or approved by the radiologist in charge.

There is universal agreement among teachers of radiology with the general principles outlined above, but there is considerable divergence of opinion as to the best manner of executing them, the order in which subjects should be taken up, and the time which should be allotted to the various subdivisions of radiology. Such differences are not only inevitable but also desirable, for radiologic education is still in the developmental stage, and its progress would be hampered by too rigid standardization at this time. Institutions vary as to the character of material at their command, and hence instructors differ in opinion as to the emphasis that should be laid on particular subjects. Because of these differences a precise and detailed plan of instruction that would be appropriate at one institution might be largely inapplicable at another. Thus The American Board of Radiology feels that it is wise to allow generous latitude in the course of training it prescribes and that at present it is inadvisable to list

and narrowly define all the subjects that might well be taught or assign definite periods of study for each of them.

Accordingly, the specifications enumerated are broad and flexible, and it will be left to the future to determine what course or combination of courses will produce the best qualified radiologists. Among exceptions to this generalization, however, the Board wishes to stress the importance of pathology as a fundamental science in radiology. Radiologic examination, diagnostic interpretation and treatment rest primarily on concepts of pathologic processes. For this reason the Board feels that at least six months of the first year should be devoted to the study of pathology and pathologic anatomy, with particular emphasis on gross pathology and that of tumors. Much of the required work in other basic sciences can be carried out along with the clinical, and no set period of time or other specification need be established at present. For example, physics can be reviewed during the study of radiotherapy. In general, the Board is of the opinion that the first year should be given to pathology and radiologic technique and toward acquiring the broad radiologic viewpoint, and that the second and third years should be given to the clinical applications of radiology, with at least six months devoted entirely to radiotherapy. Theses, advanced degrees, and original research are outside the province of present requirements.

The following is a list of diplomates of The American Board of Radiology.

DIPLOMATES OF THE AMERICAN BOARD OF RADIOLOGY

November 1, 1937

Name	Address	Field
1 Abbott, Hodson A	New York, N. Y.	Radiology
2 Abercrombie Eugene	Knoxville, Tenn.	Roentgenology
3 Abowitz Jacob	Los Angeles, Cal.	Roentgenology
4 Abraham Arden L.	Minneapolis, Minn.	Radiology
5 Achilles William E.	Geneva, N. Y.	Diagnostic Roentgenology
6 Ackemann, H. W.	Rockford, Ill.	Radiology
7 Adair Frank E.	New York, N. Y.	Therapeutic Radiology
8 Albert Simon	Providence, R. I.	Radiology
9 Alexander F. K.	Philadelphia, Pa.	Radiology
10 Algin Sergius V.	Indiana, Pa.	Diagnostic Roentgenology
11 Allen B. M.	Wilmington, Del.	Diagnostic Roentgenology
*12 Allen Bundy	Tampa, Fla.	Radiology
13 Allen Kenneth D. A.	Denver, Colo.	Radiology
14 Allen Lewis G.	Kansas City, Kans.	Radiology
15 Allen, M. Lowry	Philadelphia, Pa.	Radiology

* Deceased

16	Allen, William E , Jr	St Louis, Mo	Roentgenology
17	Alley, Reuben G	Pittsburgh, Pa	Diagnostic Roentgenology
18	Allison, R G	Minneapolis, Minn	Roentgenology
19	Altman, W S	Quincy, Mass	Radiology
20	Ames, Forrest B	Bangor, Me	Roentgenology
21	Anderson, W D	Memphis, Tenn	Roentgenology
22	Andrews J Robert	Cleveland, O	Radiology
23	Ané, J N	New Orleans, La	Radiology
24	Anspach, William E	Chicago Ill	Roentgenology
25	Archer, Vincent W	University Va	Roentgenology
26	Arens Robert A	Chicago, Ill	Radiology
27	Arneson A N	St Louis Mo	Therapeutic Radiology
28	Ashbury, Howard E	Baltimore, Md	Radiology
29	Aspray, Joseph M	Spokane, Wash	Radiology
30	Atkins, S M	Waterbury Conn	Roentgenology
31	Aurelius, J Richards	St Paul, Minn	Roentgenology
32	Avery, Philip S	New Brunswick, N J	Roentgenology
33	Bachman, M H	Youngstown O	Roentgenology
34	Bacon, Ralph D	Eric, Pa	Radiology
35	Bader E R	Cincinnati, O	Radiology
36	Bailey, C O	Los Angeles, Cal	Therapeutic Radiology
37	Bailey, Wilbur	Los Angeles Cal	Radiology
38	Baird, Joseph C	Eau Claire Wis	Roentgenology
39	Baker Charles F	Newark, N J	Roentgenology
40	Baker Edgar C	Youngstown, O	Radiology
41	Ball Clarence F	Rutland Vt	Therapeutic Radiology
42	Ball Robert P	New York, N Y	Roentgenology
43	Barfield Carter, M	Birmingham Ala	Roentgenology
44	Barker, Walter C	Philadelphia, Pa	Radiology
45	Barker, W Allen	Petersburg Va	Roentgenology
46	Barnes John M	Buffalo, N Y	Roentgenology
47	Barnett Arthur F	Eugene, Ore	Radiology
48	Barr, Richard E	Beaumont, Tex	Therapeutic Radiology
49	Barrow S C	Shreveport La	Radiology
50	Barth, Earl E	Chicago Ill	Roentgenology
51	Batchelder, Philip	Providence R I	Roentgenology
52	Bauer, August A	Chicago Ill	Roentgenology
53	Baum, Samuel M	New York N Y	Therapeutic Radiology
54	Baxter, O D	Sumter S C	Radiology
55	Beals, John A	Greenville, Miss	Radiology
56	Beeler, Raymond C	Indianapolis, Ind	Radiology
57	Beilin D S	Chicago Ill	Radiology
58	Bell, A L L	Brooklyn, N Y	Roentgenology
59	Bell, J Sheridan	Waterbury Conn	Diagnostic Roentgenology
60	Bell Joseph C	Louisville, Ky	Roentgenology
61	Bendick, Arthur J	New York N Y	Radiology
*62	Benisek Werner L	Aurora Ill	Roentgenology
63	Benjamin, Emanuel W	Providence R I	Radiology
64	Bennett James P	Chicago Ill	Roentgenology
65	Berg, H Milton	Bismarck N D	Radiology
66	Berger, Raymond A	Richmond Va	Radiology
67	Bernath Gerald J	Detroit Mich	Diagnostic Roentgenology
68	Bernstein J H	New York N Y	Radiology
69	Bertin, E J	Philadelphia Pa.	Roentgenology
70	Besser Herman	New York N Y	Radiology
71	Bethea W R	Memphis Tenn	Roentgenology
*72	Betts Arthur	Spokane, Wash	Radiology
73	Birdsall Edgar	Glens Falls N Y	Roentgenology
74	Birkbeck Norman J	Dayton, O	Radiology
75	Birkelo C C	Detroit Mich	Roentgenology
76	Bishop, Paul A	Philadelphia Pa	Radiology
77	Blackett Charles W	Boston Mass	Roentgenology
78	Blaine Edward S	Los Angeles Cal	Roentgenology
79	Blake Henry K	New York N Y	Roentgenology
80	Blake T W	Rochester Minn	Radiology
81	Bluss Gerald D	Altoona Pa	Radiology
82	Bloom, Arthur R	Detroit Mich	Roentgenology
83	Bogan Isabel K	Brookline Mass	Roentgenology
84	Bogan Mary E	Brookline, Mass	Roentgenology
85	Bogart Franklin B	Chattanooga Tenn	Roentgenology
86	Boice Ralph H	Parkersburg W Va	Radiology
87	Bonnar James M	New Bedford Mass	Radiology
88	Bonoff Karl M	Los Angeles Cal	Diagnostic Roentgenology
89	Boone William H	New York N Y	Roentgenology

* Deceased

90	Borman, C N	Minneapolis, Minn	Radiology
91	Borrelli, Frank J	New York, N Y	Diagnostic Roentgenology
92	Borzell, F F	Philadelphia, Pa	Radiology
93	Bouslog, John S	Denver, Colo	Radiology
94	Bovard, Paul G	Tarentum, Pa	Diagnostic Roentgenology
95	Bowen, Carl B	Oakland, Cal	Roentgenology
96	Bowen, David R	Philadelphia, Pa	Radiology
97	Bowie, E R	New Orleans La	Roentgenology
98	Bowing, Harry H	Rochester Minn	Therapeutic Radiology
99	Boyd, James F	Providence R I	Radiology
100	Boyes James G	Plainfield, N J	Roentgenology
101	Bradley, Robert A	Atlantic City, N J	Radiology
102	Brams, Julius	Chicago, Ill	Radiology
103	Brandenburg, H P	Denver, Colo	Radiology
104	Braun Benj D	Chicago, Ill	Radiology
105	Brennan, Francis J	Oshkosh, Wis	Diagnostic Roentgenology
106	Brenneman, R E	Meadville, Pa	Radiology
107	Bridenbaugh, J H	Billings, Mont	Radiology
108	Brittain, Oman R	Salina, Kans	Roentgenology
109	Broeser, Henry V	Hoboken, N J	Diagnostic Roentgenology
110	Bromer, Ralph S	Bryn Mawr, Pa	Radiology
111	Brooksher, W R	Fort Smith, Ark	Radiology
112	Brouse, Ivan E	Jacksonville Ill	Roentgenology
113	Brown, H O	Tampa, Fla	Roentgenology
114	Brown, Percy	Boston Mass	Roentgenology
115	Brown, Samuel	Cincinnati, O	Roentgenology
116	Bruck, Samuel	Philadelphia Pa	Radiology
117	Bryan, Lloyd	San Francisco, Cal	Roentgenology
118	Burch, Hobart A	Elmira, N Y	Radiology
119	Burcham Thomas A	Des Moines Ia	Radiology
120	Burdick Mitchell	Erie, Pa	Roentgenology
121	Burgess Charles J	Lawrence Mass	Radiology
122	Burnett H W	Dayton, O	Roentgenology
123	Butler, Nicholas G	Hartford, Conn	Radiology
124	Butler, P F	Boston Mass	Radiology
125	Caldwell Charles S	Pittsburgh, Pa	Roentgenology
126	Callen, Harold S	Bradford Pa	Radiology
127	Camp, John D	Rochester, Minn	Roentgenology
128	Campbell Lloyd A	Saginaw, Mich	Therapeutic Radiology
129	Capp Charles S	San Francisco Cal	Radiology
130	Carlson Glenn D	Dallas, Tex	Roentgenology
131	Carr Edson W	Chicago Ill	Diagnostic Roentgenology
132	Carter Ray A	Los Angeles, Cal	Roentgenology
133	Carty, John R	New York N Y	Radiology
134	Casc James T	Chicago, Ill	Radiology
135	Cassidy Raymond M	Chicago, Ill	Roentgenology
136	Catheart, John W	El Paso, Tex	Radiology
137	Challenger, Chester J	Chicago Ill	Roentgenology
138	Chamberlain, W Edward	Philadelphia Pa	Radiology
139	Chamberlain George W	Philadelphia, Pa	Radiology
140	Chapman, John F	Pasadena Cal	Roentgenology
141	Childe Arthur E	Montreal, Que	Diagnostic Roentgenology
142	Childs D S	Syracuse N Y	Roentgenology
143	Childs S B	Denver Colo	Roentgenology
144	Chilko A J	New Rochelle N Y	Roentgenology
145	Christie Arthur C	Washington D C	Radiology
146	Church, John E	Pontiac Mich	Roentgenology
147	Cilley Earl I I	Bellingham Wash	Radiology
148	Claiborne E N	New York, N Y	Radiology
149	Clapp Roland D	West Medford Mass	Radiology
150	Clark D M	Santa Barbara, Cal	Radiology
151	Clark James J	Atlanta Ga	Roentgenology
152	Clark Stanley A	South Bend Ind	Radiology
153	Clark William T	Janesville Wis	Radiology
154	Clarkson Wright	Petersburg, Va	Radiology
155	Claves Edwin N	Boston, Mass	Radiology
156	Cleghorn Charles D	Miami Fla	Diagnostic Roentgenology
157	Clement Gage	Duluth Minn	Radiology
158	Cleveland W R	Evansville Ind	Radiology
159	Climan, Max	Hartford Conn	Radiology
160	Corte J D	Oakland Cal	Diagnostic Roentgenology
161	Coe I red O	Washington D C	Radiology
162	Coffin Whitman K	Boston, Mass	Radiology
163	Cohon Carl W	Bay Shore N Y	Roentgenology
164	Colecher A Edward	Philadelphia Pa	Diagnostic Roentgenology

16	Allen, William E, Jr	St Louis, Mo	Roentgenology
17	Alley, Reuben G	Pittsburgh, Pa	Diagnostic Roentgenology
18	Alkison, R G	Minneapolis, Minn	Roentgenology
19	Altman W S	Quincy, Mass	Radiology
20	Ames, Forrest B	Bangor, Me	Roentgenology
21	Anderson, W D	Memphis Tenn.	Roentgenology
22	Andrews, J Robert	Cleveland, O	Radiology
23	Ané, J N	New Orleans, La	Radiology
24	Anspach William E	Chicago Ill	Roentgenology
25	Archer, Vincent W	University Va	Roentgenology
26	Arens, Robert A	Chicago Ill	Radiology
27	Arneson A N	St Louis Mo	Therapeutic Radiology
28	Ashbury, Howard E	Baltimore, Md	Radiology
29	Aspray, Joseph M	Spokane, Wash	Radiology
30	Atkins S M	Waterbury Conn	Roentgenology
31	Aurelius J Richards	St Paul Minn	Roentgenology
32	Avery, Philip S	New Brunswick N J	Roentgenology
33	Bachman M H	Youngstown O	Roentgenology
34	Bacon Ralph D	Erie Pa	Radiology
35	Bader, E R	Cincinnati O	Radiology
36	Bailey C O	Los Angeles, Cal	Therapeutic Radiology
37	Bailey Wilbur	Los Angeles, Cal	Radiology
38	Baird, Joseph C	Eau Claire Wis	Roentgenology
39	Baker, Charles F	Newark, N J	Roentgenology
40	Baker, Edgar C	Youngstown O	Radiology
41	Ball Clarence F	Rutland, Vt	Therapeutic Radiology
42	Ball Robert P	New York, N Y	Roentgenology
43	Barfield Carter M	Birmingham, Ala	Roentgenology
44	Barker, Walter C	Philadelphia, Pa	Radiology
45	Barker W Allen	Petersburg Va	Roentgenology
46	Barnes John M	Buffalo, N Y	Roentgenology
47	Barnett Arthur F	Eugene, Ore	Radiology
48	Barr, Richard E	Beaumont Tex	Therapeutic Radiology
49	Barrow S C	Shreveport La	Radiology
50	Barth Earl E	Chicago Ill	Roentgenology
51	Batchelder, Philip	Providence, R I	Roentgenology
52	Bauer August A	Chicago, Ill	Roentgenology
53	Baum Samuel M	New York N Y	Therapeutic Radiology
54	Baxter O D	Sumter S C	Radiology
55	Beals, John A	Greenville Miss	Radiology
56	Beeler Raymond C	Indianapolis Ind	Radiology
57	Beilin, D S	Chicago Ill	Radiology
58	Bell A L L	Brooklyn, N Y	Roentgenology
59	Bell, J Sheridan	Waterbury Conn	Diagnostic Roentgenology
60	Bell, Joseph C	Louisville, Ky	Roentgenology
61	Bendick Arthur J	New York N Y	Radiology
*62	Benishak, Werner L	Aurora, Ill	Roentgenology
63	Benjamin Emanuel W	Providence R I	Radiology
64	Bennett, James P	Chicago Ill	Roentgenology
65	Berg H Milton	Bismarck, N D	Radiology
66	Berger Raymond A	Richmond Va	Radiology
67	Bernath Gerald J	Detroit, Mich	Diagnostic Roentgenology
68	Bernstein, J H	New York N Y	Radiology
69	Bertun, E J	Philadelphia Pa	Roentgenology
70	Besser Herman	New York, N Y	Radiology
71	Bethea W R	Memphis Tenn	Roentgenology
*72	Betts Arthur	Spokane, Wash	Radiology
73	Birdsall Edgar	Glens Falls, N Y	Roentgenology
74	Birkbeck Norman J	Dayton, O	Radiology
75	Birkelo C C	Detroit Mich	Roentgenology
76	Bishop Paul A	Philadelphia, Pa	Radiology
77	Blackett Charles W	Boston Mass	Roentgenology
78	Blaine Edward S	Los Angeles Cal	Roentgenology
79	Blake Henry K	New York N Y	Roentgenology
80	Blake T W	Rochester Minn	Radiology
81	Bliss Gerald D	Altoona Pa	Radiology
82	Bloom Arthur R	Detroit Mich	Roentgenology
83	Bogan Isabel K	Brookline Mass	Roentgenology
84	Bogan Mary E	Brookline Mass	Roentgenology
85	Bogart Franklin B	Chattanooga, Tenn	Roentgenology
86	Boice Ralph H	Parkersburg W Va	Radiology
87	Bonnar, James M	New Bedford Mass	Radiology
88	Bonoff Karl M	Los Angeles Cal	Diagnostic Roentgenology
89	Boone William H	New York N Y	Roentgenology

* Deceased.

239	Drane, Robert	Savannah, Ga	Roentgenology
240	Dresser, Richard	Boston, Mass	Radiology
241	Duckworth, Roy D	White Plains, N Y	Roentgenology
242	Duckworth, Willard D	New Rochelle, N Y	Roentgenology
243	Duffy, James J	New York, N Y	Therapeutic Radiology
244	Dumas, Charles E	Worcester, Mass	Radiology
245	Dunham, H Kennon	Cincinnati, O	Diagnostic Roentgenology
246	Durrance, Fred Y	Houston, Tex	Roentgenology
247	Dyke, Cornelius G	New York, N Y	Roentgenology
248	Eastland, William E	Oklahoma City, Okla	Therapeutic Radiology
249	Eastmond, Charles	Brooklyn, N Y	Roentgenology
250	Edeken, Louis	Philadelphia, Pa	Radiology
251	Edstrom, Henry	Dubuque, Ia	Radiology
252	Edwards, Harold G F	Shreveport, La	Radiology
253	Edwards, J Bennett	Englewood, N J	Roentgenology
254	Egbert, W E	Chester, Pa	Diagnostic Roentgenology
255	Ehrenpreis, Bernard	Brooklyn, N Y	Roentgenology
256	Ehrlich, David E	New York, N Y	Radiology
257	Eisen, David	Toronto, Ont	Diagnostic Roentgenology
258	Eldridge, Watson W, Jr	Washington, D C	Roentgenology
259	Eley, Clayton W	Norfolk, Va	Roentgenology
260	Elliott, Frederic E	Brooklyn, N Y	Radiology
261	Ellis, Ivan G	Madison, Wis	Roentgenology
262	Elward, Joseph F	Washington, D C	Roentgenology
263	Eneboe, John B	San Diego, Cal	Radiology
264	Enfield, Charles D	Louisville, Ky	Radiology
265	Erickson, Lester G	South Bend, Ind	Radiology
266	Ernst, Edwin C	St. Louis, Mo	Radiology
267	Erskine, Arthur W	Cedar Rapids, Ia	Radiology
268	Ettlinger, Alice	Boston, Mass	Diagnostic Roentgenology
269	Evans, Harry D	Philadelphia, Pa	Diagnostic Roentgenology
270	Evans, John	Baltimore, Md	Roentgenology
271	Evans, William A	Detroit, Mich	Radiology
272	Eveleth, Fred S	Concord, N H	Roentgenology
273	Exner, Frederick B	Seattle, Wash	Radiology
274	Farmer, Harry L	Cleveland, O	Radiology
275	Farrell, John T, Jr	Philadelphia, Pa	Roentgenology
276	Faust, J J	Tyler, Tex	Radiology
277	Favour, Richmond, Jr	Washington, D C	Radiology
278	Feaster, O O	St. Petersburg, Fla	Radiology
279	Ferguson, James W	Pittsburgh, Pa	Radiology
280	Feuerstein, Benjamin L	Bay Shore, N Y	Therapeutic Radiology
281	Fineman, Solomon	New York, N Y	Roentgenology
282	Finkelstein, Arthur	Philadelphia, Pa	Radiology
283	Finnegan, James F	Portsmouth, Va	Roentgenology
284	Finney, Guy A	Topeka, Kans	Diagnostic Roentgenology
285	Firor, Whitmer B	Baltimore, Md	Radiology
286	Fisher, J W	Pittsburgh, Pa	Radiology
287	Fisher, L F	South Bend, Ind	Roentgenology
288	Flax, Nathan	Cincinnati, O	Roentgenology
289	Flinn, F	Decatur, Ill	Radiology
290	Flippin, Eugene L	Baltimore, Md	Radiology
291	Flynn, James M	Rochester, N Y	Radiology
292	Foley, Joseph M	Peoria, Ill	Roentgenology
293	Folkens, Frank H	Redlands, Cal	Roentgenology
294	Ford, Frances A	Detroit, Mich	Radiology
295	Fort, W A	Mare Island, Cal	Roentgenology
296	Fortier, Lucien A	New Orleans, La	Radiology
297	Fouts, Roy W	Omaha, Neb	Roentgenology
298	Francis, Herbert C	Nashville, Tenn	Roentgenology
299	Frank, Charles H	Batavia, N Y	Diagnostic Roentgenology
300	Fray, Walter W	Rochester, N Y	Radiology
301	Freedman, Eugene	Cleveland, O	Roentgenology
302	Freedman, John	Detroit, Mich	Roentgenology
303	Freid, Jacob R	New York, N Y	Radiology
304	French, Gordon S	London, Ont	Radiology
305	Frere, John M	Chattanooga, Tenn	Roentgenology
306	Fricke, Robert E	Rochester, Minn	Therapeutic Radiology
307	Friedland, Henry	New York, N Y	Diagnostic Roentgenology
308	Friedman, Asa B	Brooklyn, N Y	Radiology
309	Friedman, Harry F	Boston, Mass	Radiology
310	Friedman, Jacob	New York, N Y	Roentgenology
311	Friedman, Lewis J	New York, N Y	Diagnostic Roentgenology
312	Friedman, Max	New York, N Y	Diagnostic Roentgenology

165	Cole, J M	Windsor, Ont	Roentgenology
166	Cole, Lewis Gregory	New York, N Y	Roentgenology
167	Cole, Paul F	Springfield, Mo	Radiology
168	Cole, William Gregory	New York, N Y	Roentgenology
169	Coley, Stephen W	Memphis, Tenn	Roentgenology
170	Colgan, William S	Bridgeport Pa	Radiology
171	Collins, E N	Cleveland, O	Diagnostic Roentgenology
172	Collins, James N	Indianapolis, Ind	Radiology
173	Collins John J	Thomasville, Ga	Radiology
174	Cook, Benjamin F	Rutland, Vt	Diagnostic Roentgenology
175	Cook, Carroll E	Chicago, Ill	Diagnostic Roentgenology
176	Cook, Orrin S	Sacramento Cal	Roentgenology
177	Cook, Philip H	Worcester, Mass	Radiology
178	Cooley, R M	Jackson Mich	Roentgenology
179	Copleman Benjamin	Perth Amboy N J	Radiology
180	Coray, Q B	Salt Lake City, Ut	Roentgenology
181	Corcoran, William J	Scranton Pa	Roentgenology
182	Cornett, George W	Yakima, Wash	Roentgenology
183	Costolow, William E	Los Angeles Cal	Therapeutic Radiology
184	Covington, E Eugene	Baltimore, Md	Therapeutic Radiology
185	Cowan Irving I	Milwaukee Wis	Diagnostic Roentgenology
186	Cowherd Frank G	Cumberland, Md	Roentgenology
187	Cox Michael J	Pittsfield Mass	Roentgenology
188	Crain C F	Corpus Christi, Tex	Radiology
189	Cramp, G W	Brooklyn, N Y	Roentgenology
*190	Crane, A W	Kalamazoo, Mich	Roentgenology
191	Crawford, Helen L	Indianapolis Ind	Roentgenology
192	Crosby, Leonard G	Denver, Colo	Radiology
193	Crossan John W	Los Angeles Cal	Diagnostic Roentgenology
194	Crowder, E R	Evanston Ill	Roentgenology
195	Cummings, Edson S	Portland, Me	Roentgenology
196	Cunningham, Lester W	Mandarin Fla	Roentgenology
197	Curran Francis W	Brooklyn N Y	Roentgenology
198	Curtis Richard C	Corsicana Tex	Diagnostic Roentgenology
199	Cushway, B C	Chicago Ill	Radiology
200	D'Amico, Michael	New Haven Conn	Roentgenology
201	Dahl H W	Des Moines Ia	Diagnostic Roentgenology
202	Dann, David S	Kansas City, Mo	Radiology
203	Dannenberg Max	Brooklyn N Y	Roentgenology
204	Danzer, Joseph T	Oil City, Pa	Radiology
205	Dauksys Joseph	Excelsior Springs, Mo	Diagnostic Roentgenology
206	Davidson, S G	Bluefield, W Va	Roentgenology
207	Davidson Sol C	Rochester N Y	Roentgenology
208	Davis, Ernest L	Springfield, Mass	Roentgenology
209	Davis, F M	San Antonio Tex	Diagnostic Roentgenology
210	Davis, H E	Chicago, Ill	Radiology
211	Davis, Henry B	Lancaster Pa	Radiology
212	Davis, Kenneth S	Los Angeles, Cal	Roentgenology
213	Davison, C O	Poughkeepsie, N Y	Radiology
214	Davison, R Winthrop	Trenton N J	Roentgenology
215	Debbie, Anthony G	St Albans N Y	Diagnostic Roentgenology
216	Decker, Fred H	Peoria, Ill	Radiology
217	Deetjen Christian	Baltimore Md	Radiology
218	DeGraff, Ralph M	Buffalo N Y	Diagnostic Roentgenology
219	DeHollander, William	Springfield, Ill	Roentgenology
220	deLormier Alfred A	Ancon Canal Zone	Radiology
221	Delano, Anthony J	Paterson, N J	Radiology
222	Dempster J H	Detroit Mich	Diagnostic Roentgenology
223	Denham, Harry C	Gloversville N Y	Diagnostic Roentgenology
224	Derr, John S	Frederick Md	Roentgenology
225	Desjardins, Anatole	Wilkes-Barre Pa	Roentgenology
226	Desjardins Arthur U	Rochester Minn	Radiology
227	Dessen, Edward	Philadelphia, Pa	Diagnostic Roentgenology
228	Dessen, Louis A	Hazleton Pa	Radiology
229	Deweese E R.	Kansas City Mo	Roentgenology
230	Dick Paul G	Chicago, Ill	Roentgenology
231	Dickinson J C	Tampa Fla	Roentgenology
232	Dixon, George S	New York, N Y	Diagnostic Roentgenology
233	Donaldson S W	Ann Arbor Mich	Roentgenology
234	Doub Howard P	Detroit, Mich	Radiology
235	Doughty, William M	Cincinnati O	Radiology
236	Dowell Dawson A	Omaha Neb	Radiology
237	Downing Robert E	Terre Haute Ind	Radiology
238	Downs Elwood E	Woodbury N J	Radiology

* Deceased

387	Harris Clarence P	Houston, Tex	Roentgenology
388	Harris, John H	Harrisburg, Pa	Radiology
389	Harris, Milo T	Spokane, Wash	Radiology
390	Harris, T T	Omaha, Neb	Radiology
391	Harris, William	New York, N Y	Therapeutic Radiology
392	Hart, William E	Long Beach, Cal	Diagnostic Roentgenology
393	Hartung, Adolph	Chicago, Ill	Roentgenology
394	Hasley, Clyde K	Detroit, Mich	Radiology
395	Hatchette Stakely F	Lake Charles, La	Radiology
396	Hauser, Harry	Cleveland, O	Radiology
397	Hawley, Sydney J	Danville, Pa	Roentgenology
398	Haworth, Wallace	Portland, Ore	Radiology
399	Hay Percy D, Jr	Florence, S C	Radiology
400	Heacock, Charles H	Memphis Tenn	Roentgenology
401	Healy, Thomas R	Boston, Mass	Roentgenology
402	Heatley, John E	Oklahoma City, Okla	Diagnostic Roentgenology
403	Heberding, John	Youngstown, O	Radiology
404	Hefke Hans W	Milwaukee Wis	Radiology
405	Helmink, Mesco J	Buffalo, N Y	Diagnostic Roentgenology
406	Henderson, Samuel G	Pittsburgh, Pa	Radiology
407	Hendricks, Elliott M	Fort Lauderdale, Fla	Roentgenology
408	Hendrickson, Anna R	Canton O	Roentgenology
409	Henle Carye Belle	Newark N J	Roentgenology
410	Henry, Lucas S	Syracuse, N Y	Roentgenology
411	Herpel, Frederick K	West Palm Beach, Fla	Roentgenology
412	Herrman, W G	Asbury Park, N J	Radiology
413	Herscher, Harry	Hines, Ill	Radiology
414	Hess George H	Uniontown Pa	Roentgenology
415	Heylman Harry H	Long Beach Cal	Diagnostic Roentgenology
416	Hildreth, R C	Kalamazoo, Mich	Radiology
417	Hill, Harold A	San Francisco, Cal	Radiology
418	Hill Walter C	Cleveland, O	Roentgenology
419	Hilt, Lawrence M	Grand Rapids, Mich	Roentgenology
420	Hilton, James M	Klamath Falls, Ore	Roentgenology
421	Hirsch I Seth	New York, N Y	Radiology
422	Hocker, Alfred F	New York, N Y	Therapeutic Radiology
423	Hodes, Philip J	Philadelphia, Pa	Radiology
424	Hodges, Fred J	Ann Arbor, Mich	Radiology
425	Hodges, Fred M	Richmond, Va	Radiology
426	Hodges, Paul C	Chicago, Ill	Radiology
427	Hoffman, William J	New York, N Y	Therapeutic Radiology
428	Hoffmeier, Frank N	Hagerstown, Md	Diagnostic Roentgenology
429	Holly Leland E	Muskegon, Mich	Roentgenology
430	Holmes, George W	Boston, Mass	Radiology
431	Holmes, L P	Augusta, Ga	Roentgenology
432	Holmes, Ralph W	Chillicothe O	Roentgenology
433	Holston Joel D	Massillon O	Roentgenology
434	Holt, William	Portland Me.	Radium Therapy
435	Hopkirk, C C	Santa Monica, Cal	Roentgenology
436	Horgan, Arthur J	Springfield, Mass	Roentgenology
437	Howard, Campbell	New York N Y	Radiology
438	Howard William P	Albany, N Y	Roentgenology
439	Howes William E	Brooklyn, N Y	Radiology
440	Hubeny, M J	Chicago, Ill	Roentgenology
441	Huber, Frank	New York, N Y	Roentgenology
442	Hufford Clarence E	Toledo, O	Radiology
443	Hunt, Howard B	Omaha, Neb	Radiology
444	Hunt Russell R	Providence R I	Roentgenology
445	Hunter, James W, Jr	Norfolk, Va	Radiology
446	Hussey Frank L	Chicago, Ill	Roentgenology
447	Hutchinson R W	Chelsea, Mass	Roentgenology
448	Hutton, Frederick C	Philadelphia Pa	Roentgenology
449	Hyde Allan P	Sharon, Pa	Roentgenology
450	Hyde, X R	Fort Worth Tex	Roentgenology
451	Hynes, John F	Wilmington, Del	Therapeutic Radiology
452	Hynes William P	Washington D C	Therapeutic Radiology
453	Ikeda Kano	St Paul, Minn	Roentgenology
454	Illick, H Earl	New York, N Y	Roentgenology
455	Imboden, Harry M	New York, N Y	Roentgenology
456	Ingber Irving S	San Francisco, Cal	Radiology
457	Irwin W A	Detroit, Mich	Radiology
458	Ivey, H B	Goldsboro N C	Radiology
459	Jaches L	New York, N Y	Radiology
460	Jackson Byron H	Scranton, Pa	Radiology

313	Friedman, Milton	Newark, N J	Therapeutic Radiology
314	Friedman, Murray M	New York, N Y	Radiology
315	Fruchter, Joseph M	Philadelphia Pa	Radiology
316	Fugate Isaac T	Louisville Ky	Radiology
317	Fulmer, Charles C	San Francisco, Cal	Roentgenology
318	Fulton, Huston F	Columbus, O	Diagnostic Roentgenology
319	Furey, Warren W	Chicago Ill	Radiology
320	Furst Nathan J	Newark, N J	Diagnostic Roentgenology
321	Galanti Charles P	Chicago, Ill	Roentgenology
322	Garland L H	San Francisco Cal	Radiology
323	Garrett, Leslie M	Eau Claire, Wis	Radiology
324	Gately Tracy T	New Orleans La	Radiology
325	Gates Russell	Minto N D	Roentgenology
326	Gelehrter, Joseph	Philadelphia, Pa.	Radiology
327	Gemmell J H	Rochester Pa	Roentgenology
328	George, Ariel W	Boston, Mass	Roentgenology
329	Gerber Isaac	Providence, R I	Radiology
330	Gershon-Cohen, Jacob	Philadelphia, Pa	Radiology
331	Geyman, Milton J	Santa Barbara Cal	Diagnostic Roentgenology
332	Ghrist David M	Glendale Cal	Roentgenology
333	Gian-Franceschi, Joseph	Buffalo, N Y	Diagnostic Roentgenology
334	Gianturco, Cesare	Urbana Ill	Roentgenology
335	Giles Roy G	San Antonio Tex	Roentgenology
336	Gillies, Carl L	Cedar Rapids Ia	Radiology
337	Giltmore W M	Stratford, Ont	Radiology
338	Gingold, Joseph R	Meadville, Pa	Roentgenology
339	Glover, M H	Wichita Falls, Tex.	Radiology
340	Goin Lowell S	Los Angeles Cal	Roentgenology
341	Golden, Ross	New York N Y	Roentgenology
342	Goldman Leonard B	Jamaica, L I, N Y	Therapeutic Radiology
343	Goldsmith Maurice F	Pittsburgh Pa	Roentgenology
344	Goldstone, Karl H	West New York, N J	Roentgenology
345	Goodman Moses	Brooklyn, N Y	Radiology
346	Goodrich, Murray E	Toledo, O	Radiology
347	Goodwin Perry B	Peoria, Ill	Radiology
348	Gordon, Donald C	Scranton Pa	Radiology
349	Gorinkell Julius	Pittsburgh Pa	Diagnostic Roentgenology
350	Gorsline, Clarence S	Battle Creek Mich	Roentgenology
351	Gottlieb Charles	New York N Y	Diagnostic Roentgenology
352	Grace Joseph M	Eloise Mich	Radiology
353	Grady, Henry W	Washington D C	Radiology
354	Graham, Ralph S	Sacramento Cal	Radiology
355	Granger, Amédée	New Orleans La	Radiology
356	Gray Horace D	Memphis Tenn	Radiology
357	Green Joseph H	Rochester N Y	Roentgenology
358	Greenberg David S	Steubenville, O	Roentgenology
359	Greenberger Edward D	McAlester Okla	Radiology
360	Greenfield Henry	Brooklyn N Y	Radiology
361	Grier, G W	Pittsburgh Pa	Radiology
362	Grimm Homer W	Pittsburgh Pa	Therapeutic Radiology
363	Groark Owen J	Bridgeport, Conn	Diagnostic Roentgenology
364	Groeschel L B	New York N Y	Radiology
365	Groh Jean A	Cleveland O	Roentgenology
366	Groover, Thomas A	Washington D C	Radiology
367	Grubbe Emil H	Chicago Ill	Therapeutic Roentgenology
368	Habbe, J Edwin	Milwaukee, Wis	Roentgenology
369	Hackler, Robert H Jr	Washington N C	Roentgenology
370	Hackney Urban P	Dallas Tex	Radiology
371	Hadley Lee A	Syracuse N Y	Roentgenology
372	Hall E Walter	Detroit Mich	Radiology
373	Hall, Robert C	Utica N Y	Roentgenology
374	Hall, Wendell C	Philadelphia Pa	Radiology
375	Halley Edmund P	Decatur, Ill	Radiology
376	Hamilton, Charles M	Nashville, Tenn.	Radiology
377	Hamilton W S	San Antonio Tex	Diagnostic Roentgenology
378	Hampton, A O	Boston Mass	Radiology
379	Hankins, John L	Johnson City Tenn	Roentgenology
380	Hansen Cyrus O	Minneapolis Minn	Radiology
381	Harding, D B	Lexington Ky	Radiology
382	Hardy, Clyde C	Omaha Neb	Diagnostic Roentgenology
383	Hare Hugh F	Boston Mass	Radiology
384	Harrell Henry C	Texarkana Tex	Roentgenology
385	Harrington B D	Tacoma Wash	Radiology
386	Harrington, Leo A	Brooklyn N Y	Diagnostic Roentgenology

461	Jackson, John B	Kalamazoo, Mich	Roentgenology
462	Jacobs Alexander W	New York, N Y	Therapeutic Radiology
463	Jacobs Lewis G, Jr	Madison, Wis	Radiology
464	Jacob, Harold W	Pittsburgh, Pa.	Radiology
465	Jahn, Albert G	Passaic, N J	Roentgenology
466	Jarre Hans A	Detroit, Mich	Radiology
467	Jenkinson, David L	Chicago, Ill	Roentgenology
468	Jenkinson, E L	Chicago, Ill	Radiology
469	Jewell, Earl B	Fort Dodge, Ia	Roentgenology
470	Johannesson, Carl J	Walla Walla, Wash.	Roentgenology
471	Johns Erwin W	Albuquerque, N M	Radiology
472	Johnson Brantley M	Chicago, Ill	Roentgenology
473	Johnson, Clayton R	Los Angeles Cal	Roentgenology
474	Johnson, Ellsworth	Winchester, Va	Roentgenology
475	Johnson, Jesse B	Galveston, Tex	Radiology
476	Johnson, Sydney E	Louisville, Ky	Diagnostic Roentgenology
477	Johnson Vincent C	Ann Arbor, Mich	Radiology
478	Johnston Zoe Allison	Pittsburgh Pa	Therapeutic Radiology
479	Jones, Clifford F	Cleveland O	Roentgenology
480	Jones, Horace C	Detroit Mich	Radiology
481	Jones J William	Pottsville, Pa	Radiology
482	Jones Oscar O	Shreveport La	Roentgenology
483	Jones William A	Kingston, Ont	Radiology
484	Judson, Herbert A	Los Angeles, Cal	Roentgenology
485	Judy, William S	Greenville S C	Radiology
486	Kabakjian, Armen E	Lancaster, Pa	Radiology
487	Kahn, Max	Baltimore, Md	Roentgenology
488	Kalbfleisch, William K.	Wheeling W Va	Roentgenology
489	Kann, U S	Binghamton N Y	Radiology
490	Kaplan Ira I	New York, N Y	Therapeutic Radiology
491	Kaplan, Morris	New York, N Y	Diagnostic Roentgenology
492	Kapo Peter J	Mahanoy City, Pa	Radiology
493	Kasabach, Haig H	New York, N Y	Radiology
494	Kautz Friedrich G	New York, N Y	Roentgenology
495	Kean, Albert	New York, N Y	Therapeutic Radiology
496	Keddy Russell A	Stamford, Conn	Diagnostic Roentgenology
497	Keichline, John M	Huntingdon, Pa	Radiology
498	Keith, David Y	Louisville Ky	Radiology
499	Kelley Jacob S	Providence R. I	Roentgenology
500	Kellogg, John O	San Diego Cal	Radiology
501	Kelly, James F	Omaha Neb	Radiology
502	Kenning, John C	Detroit Mich	Radiology
503	Kerby James P	Salt Lake City, Ut	Roentgenology
504	Kerr, H Dabney	Iowa City Ia	Radiology
505	Kesmodel Karl F	Birmingham, Ala	Radiology
506	Kibby Sydney V	Los Angeles, Cal	Diagnostic Roentgenology
507	Kidder, Frank W	Los Angeles Cal	Diagnostic Roentgenology
508	Kilby, Walter L	Baltimore Md	Radiology
509	King, Earl H	Saratoga Springs N Y	Roentgenology
510	King J Cash	Memphis Tenn	Radiology
511	Kinney Kenneth K	Willimantic, Conn	Roentgenology
512	Kinney Lyell C	San Diego Cal	Radiology
513	Kinney, Mila A Jackson	Los Angeles Cal	Radiology
514	Kirkland A Stanley	St John N B	Roentgenology
515	Kirklin B R	Rochester, Minn	Radiology
516	Klapproth Herman	Halstead, Kans	Roentgenology
517	Klein William	New Brunswick N J	Radiology
518	Klostermyer L L	Warsaw N Y	Diagnostic Roentgenology
519	Knapp, John C	Woodhaven L I N Y	Radiology
520	Knight, Russell W	Brantford Ont	Radiology
521	Koransky Gennady H	Long Island City N Y	Diagnostic Roentgenology
522	Kolvoord, Theodore	Battle Creek Mich	Diagnostic Roentgenology
523	Kornblum, Karl	Philadelphia Pa	Radiology
524	Kraft Ernest	New York, N Y	Roentgenology
525	Kuegle, F H	Janesville Wis	Roentgenology
526	Kugler, Joseph C	Jackson Mich	Roentgenology
527	Kuhlman, Fred Y	Springfield Ill	Roentgenology
528	Kurz Bernard	Bronx N Y	Diagnostic Roentgenology
529	Lachmann Ernst	Oklahoma City, Okla	Radiology
530	Lafferty, R. H	Charlotte N C	Radiology
531	Lamb Frank W	Portland Me	Diagnostic Roentgenology
532	Lampe Isadore	Ann Arbor Mich	Radiology
533	Landau, George M	Chicago Ill	Roentgenology
534	Landes W L S	York, Pa	Roentgenology

684	Morse Russell W	Minneapolis Minn	Roentgenology
685	Morton, S A	Milwaukee Wis	Radiology
686	Moses, Chester D	Buffalo, N Y	Diagnostic Roentgenology
687	Mosteller, Malcolm	Columbia, S C	Radiology
688	Mostrom H T	Batavia, Ill	Radiology
689	Movness, Bennie A	Dayton, O	Diagnostic Roentgenology
690	Mueller W K	St Louis, Mo	Diagnostic Roentgenology
691	Mulligan, Peter B	Ashland, Pa	Roentgenology
692	Murphy G W	Asheville, N C	Roentgenology
693	Murphy, J T	Toledo, O	Radiology
694	Myers, Ralph E	Oklahoma City, Okla	Radiology
695	Napper, Marvin L	Tulsa Okla	Roentgenology
696	Naslund, Ames W	St Paul, Minn	Roentgenology
697	Nathanson Louis	Brooklyn, N Y	Radiology
698	Nelson, Peter A	Chicago, Ill	Therapeutic Radiology
699	Nessa, N J	Sioux Falls S D	Roentgenology
700	Newcomer, Nathan B	Denver, Colo	Radiology
701	Newcomer William S	Philadelphia Pa	Radiology
702	Newell, Robert R	San Francisco, Cal	Radiology
703	Nichols B H	Cleveland, O	Radiology
704	Nichols, Harold E	Seattle Wash	Diagnostic Roentgenology
705	Noble, Robert P	Raleigh N C	Roentgenology
706	Nordin, Gustaf T	Minneapolis, Minn	Radiology
707	O Bannon R P	Fort Worth Tex	Radiology
708	O'Boyle Cyril P	Philadelphia Pa	Radiology
709	O'Brien Frederick W	Boston Mass	Radiology
710	O'Connell, Andrew E	Worcester Mass	Roentgenology
711	O'Neill John R	San Francisco Cal	Roentgenology
712	Ochsner Harold C	Indianapolis Ind	Radiology
713	Oder Charles	Jersey City, N J	Roentgenology
714	Oechsl Waldo R	Olive View, Cal	Diagnostic Roentgenology
715	Oehlbeck Luther W	Clifton Springs, N Y	Roentgenology
716	Ogden, Ralph T	Hartford Conn	Radiology
717	Olin, Harry	Chicago Ill	Roentgenology
718	Orndoff B H	Chicago Ill	Radiology
719	Orr Clifford R	Buffalo N Y	Radiology
720	Osgood Herman A	Boston, Mass	Roentgenology
721	Osmond John D	Cleveland O	Roentgenology
722	Osmond Leslie H	Pittsburgh Pa	Radiology
723	Ossip Abraham	New York N Y	Diagnostic Roentgenology
724	Ostro Marcus	Baltimore Md	Roentgenology
725	Ostrum Herman W	Philadelphia Pa	Roentgenology
726	Ourian Adom K	New York N Y	Diagnostic Roentgenology
727	Overgaard Anders P	Omaha Neb	Radiology
728	Owen Arthur K	Topock, Kans	Roentgenology
729	Owen Colin C	San Bernardino Cal	Roentgenology
730	Pack, George T	New York N Y	Therapeutic Radiology
*731	Paune Robert	Memphis Tenn	Radiology
732	Pallen Coade de S	Rochelle Park, N J	Therapeutic Radiology
733	Palmer Dorwin L	Portland, Ore	Radiology
734	Pancoast Henry K	Philadelphia, Pa	Radiology
735	Parker Carl H	Pasadena Cal	Roentgenology
736	Parker Eugene M	Houston, Tex	Roentgenology
737	Parmelee B M	Bridgeport, Conn	Radiology
*738	Parry Leo D	Easton Pa	Radiology
739	Paterson Robert K	Ottawa Ont	Radiology
740	Paul Lester W	Kansas City Mo	Radiology
741	Pawling Jesse R	Watertown N Y	Diagnostic Roentgenology
742	Payton Frazier J	Miami Beach, Fla	Radiology
743	Peake John D	Mobile Ala	Radiology
744	Peck Willis S	Ann Arbor Mich	Radiology
745	Peden Joseph C	St Louis, Mo	Roentgenology
746	Peirce Carleton B	Ann Arbor Mich	Radiology
747	Pendergrass E P	Philadelphia Pa	Radiology
748	Pendergrass Robert C	Americus Ga	Roentgenology
749	Pepe John	Brooklyn N Y	Roentgenology
750	Percival Milton F	Philadelphia Pa	Radiology
751	Perkins Charles W	Norwalk Conn	Roentgenology
752	Perkins Roy S	Boston, Mass	Roentgenology
753	Perlberg Harry J	Jersey City N J	Roentgenology
754	Perley Arthur E	Waterloo Ia	Radiology
755	Perry Gentz	Evanston Ill	Radiology

* Deceased

609	McGehee, William H	Fresno Cal	Roentgenology
610	McGlothlan, Arthur B	St Joseph, Mo	Radiology
611	McGregor, William J	Wilkesburg, Pa	Roentgenology
612	McGuffin, W Herbert	Calgary, Alberta	Radiology
613	McHenry, Rupert K.	Houston, Tex	Roentgenology
614	McIntosh, Harriet C	New York, N Y	Roentgenology
615	McKinney, Joseph T	Roanoke, Va	Roentgenology
616	McNabb, Atholl M	Ottawa Ont	Roentgenology
617	McNamee, Edgar P	Cleveland, O	Roentgenology
618	McNutt, John R	Duluth, Minn	Radiology
619	McPeak, Clarence N	Fitchburg Mass	Roentgenology
620	McPeak, Edgar M	Washington D C	Radiology
621	Macmillan, A S	Boston, Mass	Diagnostic Roentgenology
622	Maddox, William H	Wauseon O	Diagnostic Roentgenology
623	Magruder, L Freeland	Norfolk, Va	Radiology
624	Mahrer, Herbert A	Cleveland O	Roentgenology
625	Maier, Roe J	Chicago, Ill	Radiology
626	Malcolmson, Patrick H	Edmonton, Alberta	Radiology
627	Malone, Leander A	Terre Haute, Ind	Radiology
628	Mandeville, Frederick B	Richmond, Va	Radiology
*629	Manges, Willis F	Philadelphia, Pa	Radiology
630	Marchbanks, S S	Chattanooga, Tenn	Radiology
631	Marks, Hirsch	New York, N Y	Therapeutic Radiology
632	Marks, Joseph H	Fall River, Mass	Roentgenology
633	Marquis, W James	Newark, N J	Roentgenology
634	Martin, Charles L	Dallas, Tex	Radiology
635	Martin, Hayes E	New York, N Y	Therapeutic Radiology
636	Martin, James M	Dallas, Tex	Radiology
637	Martin, Thomas W	Port Arthur, Tex.	Diagnostic Roentgenology
638	Martin, W C	Louisville, Ky	Roentgenology
639	Mason, Claude H	El Paso, Tex	Diagnostic Roentgenology
640	Massaro, Alfonso F	New York, N Y	Diagnostic Roentgenology
641	Masterson, John J	Brooklyn, N Y	Roentgenology
642	Matlack, James A	Longmont, Colo	Diagnostic Roentgenology
643	Matthews, Cora A	Evanston, Ill	Roentgenology
644	Mattick, Walter L	Buffalo, N Y	Radiology
645	Maver, William W	Jersey City, N J	Roentgenology
646	Mawhinney, Harvey N	Pittsburgh, Pa	Diagnostic Roentgenology
647	May, Ernst A	East Orange, N J	Radiology
648	May, Raymond V	Cleveland, O	Radiology
649	May, Robert J	Cleveland, O	Radiology
650	Mayfield, Claud	Long Beach, Cal	Diagnostic Roentgenology
651	Meadows, James A	Birmingham, Ala	Radiology
652	Means, Hugh J	Columbus, O	Radiology
653	Medelman, John P	St Paul, Minn	Roentgenology
654	Meland, Orville N	Los Angeles, Cal	Therapeutic Radiology
655	Meltzer, Samuel L	Portsmouth, O	Diagnostic Roentgenology
656	Mendelson, Emanuel	Brooklyn, N Y	Roentgenology
*657	Menees, Thomas O	Grand Rapids, Mich	Radiology
658	Menville, Leon J	New Orleans, La	Radiology
659	Merchant, Albert K	Philadelphia, Pa	Radiology
660	Merrill, E Forrest	New York, N Y	Roentgenology
661	Merritt, E A	Washington, D C	Radiology
662	Mesirov, Sidney D	Chicago, Ill	Roentgenology
663	Meter, Edward G	Reading, Pa	Radiology
664	Meyer, Keith T	Evansville, Ind	Roentgenology
665	Meyer, William H	New York, N Y	Radiology
666	Miles, John M	New Orleans, La	Diagnostic Roentgenology
667	Milkman, Louis A	Scranton, Pa	Roentgenology
668	Miller, Harry A	Baltimore, Md	Radiology
669	Miller, Russel F	Philadelphia, Pa	Radiology
670	Miltwee, Robert H	Dallas, Tex	Radiology
671	Ming, Charles M	Oklmulgee, Okla	Radiology
672	Minor, Edward G	Detroit, Mich	Diagnostic Roentgenology
673	Moffatt, F J	Medford, Ore	Diagnostic Roentgenology
674	Moloney, Albert M	Boston, Mass	Roentgenology
675	Moore, Alexander B	Washington, D C	Radiology
676	Moore, Claude	Washington, D C	Radiology
677	Moore, Daniel M	Monroe, La	Roentgenology
678	Moore, John J	San Francisco, Cal	Radiology
679	Moore, Paul D	Muncie, Ind	Radiology
680	Moore, Sherwood	St Louis, Mo	Radiology
681	Moore, Vernor M	Grand Rapids, Mich	Radiology
682	Morrison, Murray C	London, Ont.	Radiology
683	Morrison, Sidney L	Boston, Mass	Roentgenology

* Deceased

827	Rice, Frank M	San Francisco, Cal	Roentgenology
828	Richards Charles M	San Jose, Cal	Radiology
829	Richman, Samuel	New York, N Y	Radiology
830	Richman Samuel H	Chicago Ill	Diagnostic Roentgenology
831	Riebel, Frank A	Columbus, O	Radiology
832	Rigler, Leo G	Minneapolis, Minn	Radiology
833	Ritvo, Max	Boston, Mass	Radiology
834	Ritzman, Allen Z	Harrisburg, Pa	Roentgenology
835	Roberts, Douglas J	Hartford, Conn	Radiology
836	Roberts Joseph E, Jr	Camden, N J	Radiology
837	Robin Nathaniel H	Hempstead N Y	Roentgenology
838	Robin, Percival A	Hempstead, N Y	Roentgenology
839	Robins, Samuel A	Boston, Mass	Roentgenology
840	Robinson G Allen	New York N Y	Therapeutic Radiology
*841	Robinson Ralph V	Pittsburgh, Pa	Roentgenology
842	Robinson Walter W	Memphis Tenn	Roentgenology
843	Rodenbaugh, F H	San Francisco Cal	Radiology
844	Rodgers, Floyd D	Columbia, S C	Radiology
845	Rodick J C	New Orleans, La	Roentgenology
846	Rodriguez Juan	Fort Wayne, Ind	Radiology
847	Roemer, Jacob	Paterson, N J	Radiology
*848	Roland Marion M	Oklahoma City, Okla	Therapeutic Radiology
849	Rona Maurice	New Brunswick, N J	Roentgenology
850	Rork, Lee W	Hastings Neb	Roentgenology
851	Rose Cassie B	Boulder Colo	Radiology
852	Rosenbaum, George	Philadelphia, Pa	Diagnostic Roentgenology
853	Rosh, Rieva	New York N Y	Therapeutic Radiology
854	Rothnem Thomas P	Fargo N D	Roentgenology
855	Rousseau J P	Winston Salem, N C	Radiology
856	Rowe, Edward W	Lincoln, Neb	Radiology
857	Rowell Edward E	Stamford Conn	Roentgenology
858	Rubenfeld Sidney	New York N Y	Therapeutic Radiology
859	Rubert Samuel R	Chicago, Ill	Roentgenology
860	Rude, Joe C	New York, N Y	Radiology
861	Rudisill Hillyer, Jr	Charleston, S C	Radiology
862	Ruggles, Howard E	San Francisco Cal	Roentgenology
863	Rulison, Foster C	Syracuse N Y	Roentgenology
864	Rutledge Clifford P	Shreveport La	Radiology
865	Ryan, Eric J	New York N Y	Roentgenology
866	Rypins Edwin L	Bloomington, Ill	Radiology
867	Samuel, Ernest C	New Orleans, La	Roentgenology
868	Sanderson Stevens S	Detroit Mich	Radiology
869	Sante L R	St Louis Mo	Radiology
870	Sargent William H	Oakland Cal	Radiology
871	Schatzki, Richard	Boston Mass	Radiology
872	Schechter, Samuel	New York N Y	Diagnostic Roentgenology
873	Schenck, Samuel G	Brooklyn N Y	Radiology
874	Schummelpfennig R. D	Montclair N J	Roentgenology
875	Schmidt Ernst A	Denver, Colo	Radiology
876	Schmitz Henry	Chicago Ill	Therapeutic Radiology
877	Schmitz Walter A	Middletown, N Y	Roentgenology
878	Schnack A G	Honolulu, Hawaii	Radiology
879	Schoebelen, Paul C	St Louis Mo	Roentgenology
880	Schons Edward	St Paul, Minn	Radiology
881	Schreiner Bernard F	Buffalo, N Y	Therapeutic Radiology
882	Schumacher F L	Pittsburgh, Pa	Radiology
883	Schwartz Charles W	New York, N Y	Roentgenology
884	Schwartz Irving	New York N Y	Diagnostic Roentgenology
885	Scott Clifton R	New Haven Conn	Roentgenology
886	Scott Walter R	Niagara Falls, N Y	Roentgenology
887	Scott, Wendell G	St Louis Mo	Radiology
888	Scott Wilhelmina S	Lancaster Pa	Radiology
889	Seeds, Asa E	Spokane Wash	Radiology
890	Sender Arthur C	Philadelphia Pa	Roentgenology
891	Seward William H	Orange N J	Radiology
892	Shapiro Abraham V	Brooklyn N Y	Diagnostic Roentgenology
893	Shapiro, William M	Toledo O	Radiology
894	Sharpe A. Maxwell	Chester Pa	Roentgenology
895	Shaw W McL	Jacksonville, Fla	Roentgenology
896	Shebesta Emil M	Detroit, Mich	Radiology
897	Sheldon, Francis B	Stockton Cal	Radiology
898	Sheridan, William M	Spartanburg S C	Radiology
*899	Sherman Herbert deG	White Plains, N Y	Diagnostic Roentgenology
900	Sherrick Earl C	Connellsville Pa	Diagnostic Roentgenology

* Deceased

756	Perry, Solomon P	Sayre Pa	Radiology
757	Peters, Anthony E	Auburn, Me	Roentgenology
758	Peters Chester M	Canton O	Radiology
759	Peters Jesse J	Tuskegee, Ala	Diagnostic Roentgenology
760	Peterson Charles H	Roanoke, Va	Roentgenology
761	Peterson George E	Waukesha, Wis	Radiology
762	Peterson, V L	Charleston W Va	Radiology
763	Petrie E A	St John, N B	Roentgenology
764	Pett Robert G	Pittsburgh, Pa	Radiology
765	Pettit, Roswell T	Ottawa Ill	Therapeutic Radiology
766	Pfahler, G E	Philadelphia Pa	Radiology
767	Pfeffer, Theodore J	Racine, Wis	Radiology
768	Philips, Herman B	New York N Y	Radiology
769	Phillips, Clyde C	Charlotte, N C	Radiology
770	Pierce, Harold J	Terre Haute Ind	Radiology
771	Pierson John W	Baltimore Md	Radiology
772	Pigott, Albert W	Skillman, N J	Diagnostic Roentgenology
773	Pindell, Merl L	Los Angeles, Cal	Diagnostic Roentgenology
774	Pines, John A	Orlando, Fla	Therapeutic Roentgenology
775	Pirie, A H	Montreal Que	Radiology
776	Pitman James F	Lake City, Fla	Roentgenology
777	Pitts Thomas A	Columbia S C	Roentgenology
778	Plehn, George J	New York, N Y	Diagnostic Roentgenology
*779	Podlasky, Harry B	Milwaukee, Wis	Roentgenology
780	Pohle, E A	Madison, Wis	Therapeutic Radiology
781	Pomeranz Maurice M	New York N Y	Radiology
782	Pomeranz Raphael	Newark, N J	Roentgenology
783	Pomeroy Lawrence A	Cleveland O	Radium Therapy
784	Pool Harry H	Pontiac, Mich	Roentgenology
785	Popoff Constantine	Haverhill Mass	Diagnostic Roentgenology
786	Popp Walter C	Rochester Minn	Therapeutic Radiology
787	Poppel Maxwell H	New York N Y	Diagnostic Roentgenology
788	Porter, Horace W	Jackson Mich	Radiology
789	Portmann U V	Cleveland O	Radiology
790	Post, Joseph W	Philadelphia, Pa	Diagnostic Roentgenology
791	Potter Carlton F	Syracuse N Y	Roentgenology
792	Potter, Hollis E	Chicago Ill	Roentgenology
793	Potter, Roy P	Marshfield Wis	Roentgenology
794	Pound Robert E	New York N Y	Roentgenology
795	Powell E V	Temple Tex	Radiology
796	Powers, Martin T	Utica N Y	Diagnostic Roentgenology
797	Powers, Richard T	Springfield, Mass	Radiology
798	Powers, Robert A	Palo Alto Cal	Radiology
799	Present, Arthur J	New York, N Y	Radiology
800	Price, R J	Dayton, O	Radiology
801	Prouty, J V	Terre Haute, Ind	Radiology
802	Putts, B Swayne	Eric, Pa	Roentgenology
803	Quick, Douglas	New York, N Y	Therapeutic Radiology
804	Quigley, D T	Omaha Neb	Radium Therapy
805	Quimby A Judson	New York N Y	Roentgenology
*806	Quiney, James J	Easton Pa	Radiology
807	Quinlan, Catherine M	Santa Rosa Cal	Roentgenology
808	Raap Gerard	Miami, Fla	Radiology
809	Radding, Moses B	Elizabeth N J	Radiology
810	Rathbone Ralph R.	Washington D C	Radiology
811	Rauschenbach, Charles W	Hammond, Ind	Roentgenology
812	Ravold, Henry J	St Joseph Mo	Radiology
813	Ray, William B G	Pittsburgh, Pa	Roentgenology
814	Reaves Hugh G	Knorrville, Tenn	Roentgenology
815	Reed, Charles B	Newburgh, N Y	Roentgenology
816	Rees, Sherman E	Portland Ore	Radiology
817	Reeves Robert J	Durham N C	Radiology
818	Reiley Wilham E	Clearfield, Pa	Radiology
819	Reineke Harold G	Cincinnati O	Roentgenology
820	Reitter, George S	East Orange N J	Radiology
821	Remer, John	New York N Y	Therapeutic Roentgenology
822	Rendich, Richard A.	Brooklyn N Y	Roentgenology
823	Reynolds Gardner S	Walker, Minn	Diagnostic Roentgenology
824	Reynolds Lawrence	Detroit Mich	Radiology
825	Rhinehart Darmon A	Little Rock Ark.	Roentgenology
826	Rhudy Booker E	Greensboro N C.	Roentgenology

976	Swenson, Paul C	New York, N Y	Roentgenology
977	Swope, Opie W	Wichita, Kans	Radiology
978	Sycamore, Leslie K	Hanover, N H	Radiology
979	Tabb, John L, Jr	Richmond, Va	Roentgenology
980	Taft Robert B	Charleston, S C	Radiology
981	Talley, Daniel D, Jr	Richmond, Va	Roentgenology
982	Tamarkin, Saul J	Youngstown, O	Radiology
983	Taormina, Louis J	Brooklyn, N Y	Diagnostic Roentgenology
984	Taylor, Clifford C	Indianapolis, Ind	Radiology
985	Taylor, Henry K	New York N Y	Diagnostic Roentgenology
986	Taylor, Raymond G	Los Angeles, Cal	Radiology
987	Taylor, Richard T	Los Angeles, Cal	Radiology
988	Teitelbaum, Meyer D	New Orleans, La	Roentgenology
989	Templeton, Frederic E	Chicago, Ill	Radiology
990	Tennis, Matthew N	Fall River, Mass	Roentgenology
991	Thaxter, Langdon T	Portland, Me	Roentgenology
992	Thomas, Camp C	Lewiston, Me	Roentgenology
993	Thomas, M A	Cleveland, O	Radiology
994	Thompson, Harold B	Seattle Wash	Radiology
995	Thureson Paul F	Riverside, Cal	Roentgenology
996	Tice, Galen M	Kansas City Kans	Radiology
997	Tichy L S	Chicago, Ill	Roentgenology
998	Tidaback, John D	Summit N J	Roentgenology
999	Titterington, Paul F	St Louis Mo	Roentgenology
1000	Tivnan, Paul E	Salem Mass	Radiology
1001	Treves Norman	New York N Y	Therapeutic Radiology
1002	Troje Oscar R	Fairfield, Ala	Radiology
1003	Trostler, Isador S	Chicago, Ill	Radiology
1004	Troup, Ralph L	Green Bay Wis	Radiology
1005	Troxell, William C	Allentown Pa	Roentgenology
1006	Trueheart Marion	Sterling, Kans	Radiology
1007	Tuggle Allan	New York N Y	Radiology
1008	Turnbull, Andrew	Durham N C	Radiology
1009	Tyler Albert F	Omaha, Neb	Radiology
1010	Ude, Walter H	Minneapolis Minn	Roentgenology
1011	Ulbrich Henry L	Detroit Mich	Roentgenology
1012	Ullmann, Henry J	Santa Barbara, Cal	Radiology
1013	Unfug, George A	Pueblo, Colo	Radiology
1014	Unger, Arthur S	New York, N Y	Roentgenology
1015	Upton, Wilbur O	Battle Creek, Mich	Radiology
1016	Van Allen, Harvey W	Springfield Mass	Radiology
1017	Van Atta, J R	Albuquerque, N M	Radiology
1018	Van Buskirk, Edmund M	Fort Wayne, Ind	Roentgenology
1019	Van Nuys Roscoe G	Berkeley Cal	Radiology
1020	Van Winkle LeRoy P	Brooklyn N Y	Diagnostic Roentgenology
1021	Vance Robert G	Boston, Mass	Roentgenology
1022	Vastine Jacob H	Philadelphia, Pa	Radiology
1023	Velkoff Metodi	Fort Wayne Ind	Roentgenology
1024	Vinnedge Kenneth H	Newport R I	Roentgenology
1025	Virden C Edgar	Kansas City Mo	Radiology
1026	Vogt, Edward C	Boston Mass	Roentgenology
1027	Voke, Edward L	Akron O	Radiology
1028	Volderauer, John C	Kalamazoo, Mich	Radiology
1029	Voltz, Albert L	Richmond Hill, N Y	Roentgenology
1030	von Poswick, Gisela	Scranton, Pa	Roentgenology
1031	Wachowski, T J	Chicago Ill	Roentgenology
1032	Walker, Howard M	Fort Worth, Tex	Radiology
1033	Wallace K K	Norfolk Va	Radiology
1034	Walton, Henry J	Baltimore Md	Radiology
1035	Wanninger W J	Chicago Ill	Diagnostic Roentgenology
1036	Ward, Charles B	Seattle Wash	Therapeutic Radiology
1037	Ward Grant E	Baltimore Md	Radium Therapy
1038	Warden Marine R	Albuquerque N M	Roentgenology
1039	Warfield, Chester H	Wichita, Kans	Roentgenology
1040	Warren Alva H	Malden Mass	Diagnostic Roentgenology
1041	Wasch, Milton G	Brooklyn N Y	Radiology
1042	Wasson W W	Denver, Colo	Radiology
1043	Waters Charles A	Baltimore Md	Radiology
1044	Watkins W Warner	Phoenix, Ariz	Radiology
1045	Weaver Clarence E	Detroit Mich	Radiology
*1046	Webb, James A H	Wichita, Kans	Roentgenology

901	Shetter North W	Lakewood, O	Roentgenology
902	Shifflett E Lee	Louisville, Ky	Roentgenology
903	Shoemaker Robert, 3rd	Philadelphia, Pa	Radiology
904	Shohan, Joseph	Greensboro N C	Roentgenology
905	Shore O J	Detroit Mich	Diagnostic Roentgenology
906	Shoulders, H S	Nashville, Tenn	Radiology
907	Shull, J Rush	Charlotte, N C	Roentgenology
908	Shulman, Simon	Far Rockaway, N Y	Roentgenology
909	Sichler Harper G	Lafayette, Ind	Radiology
910	Sickels, Thomas N	Watertown, N Y	Roentgenology
911	Siefert, Alfred C	Oakland, Cal	Radiology
912	Sigman, Frederick G	Salisbury N C	Roentgenology
913	Sims, George P	Columbus, O	Therapeutic Radiology
914	Simberg, Samuel E	New York N Y	Diagnostic Roentgenology
915	Singleton, Arthur C	Toronto Ont	Radiology
916	Skinner Edward H	Kansas City, Mo	Radiology
917	Skomp, C E	Denver, Colo	Diagnostic Roentgenology
918	Smedal M I	Boston Mass	Radiology
919	Smith, Arthur B	La Jolla Cal	Diagnostic Roentgenology
920	Smith, B B	Buffalo, N Y	Diagnostic Roentgenology
921	Smith, Jerome H	San Angelo, Tex	Radiology
922	Smith, Lester A	Indianapolis Ind	Radiology
923	Smith, Richard L	Santa Monica, Cal	Radiology
924	Smith, R Manges	Philadelphia Pa	Roentgenology
925	Smith Roscoe L	Lincoln Neb	Radiology
926	Smyth Thomas L	Allentown Pa	Roentgenology
927	Snead, Lawrence O	Richmond, Va	Roentgenology
928	Snedden, Alexander R.	McKeesport Pa	Diagnostic Roentgenology
929	Snoke Paul O	Lancaster Pa	Radiology
930	Snow, Henry	Dayton, O	Radiology
931	Snow William	New York, N Y	Roentgenology
932	Snuce, Henry	Los Angeles, Cal	Roentgenology
933	Soiland, Albert	Los Angeles Cal	Radiology
934	Solis Cohen, Leon	Philadelphia, Pa	Radiology
935	Sosman M C	Boston Mass	Radiology
936	Soule Arthur B, Jr	Burlington Vt	Roentgenology
937	Spackman, Edgar W	Philadelphia, Pa	Radiology
938	Spangler, Davis	Dallas Tex	Radiology
939	Spencer, Hunter B	Lynchburg, Va.	Roentgenology
940	Spencer, Jack	Boston Mass	Radiology
941	Spies, John W	Bombay, India	Therapeutic Radiology
942	Spillman, Ramsay	New York, N Y	Diagnostic Roentgenology
943	Spilman Harold A	Ottumwa Ia	Roentgenology
944	Spinzig, Edgar W	St Louis, Mo	Radiology
945	Sproull, John	Haverhill, Mass	Roentgenology
946	Squire, Fay H	Chicago, Ill	Roentgenology
947	Stafford Owen R	Los Angeles Cal	Therapeutic Roentgenology
948	Stall, Arthur H	Akron O	Radiology
949	Stammel Charles A	Fort Benning Ga.	Diagnostic Roentgenology
950	Starks, Dorothy J	Palo Alto Cal	Radiology
951	Startz, Irving S	Elmhurst N Y	Roentgenology
952	Stayton, Chester A	Indianapolis Ind	Radiology
953	Stecher, William R	Darby, Pa	Radiology
954	Steel David	Cleveland O	Roentgenology
955	Stein Justin J	Hines Ill	Therapeutic Radiology
956	Steinberg, Samuel S	Butte Mont	Radiology
957	Steiner Joseph M	New York N Y	Roentgenology
958	Stenstrom Annette T	Minneapolis Minn.	Diagnostic Roentgenology
959	Stephenson F B	Denver Colo	Radiology
960	Stevens, R H	Detroit Mich	Radiology
961	Stewart, Harry M	Johnstown Pa	Radiology
962	Stewart Melba D	Lacoma, N H	Roentgenology
963	Stewart Ralph C	Lowell Mass	Roentgenology
964	Stewart, Wendell	East St Louis, Ill	Diagnostic Roentgenology
965	Stewart, William H	New York N Y	Roentgenology
966	Stiles Henry T	Cleveland O	Roentgenology
967	Stocking Bruce W	New York, N Y	Radiology
968	Stone, Robert S	San Francisco, Cal	Roentgenology
969	Stowe Irving E	Portsmouth N H	Diagnostic Roentgenology
970	Strauss, Abraham	Cleveland O	Radium Therapy
971	Strauss Hyman	Brooklyn N Y	Radium Therapy
972	Stuart, Leon H	Tulsa Okla	Roentgenology
973	Sussman, Marcy L	New York N Y	Radiology
974	Sutherland, Charles G	Rochester Minn	Diagnostic Roentgenology
975	Swearingen Forrest C	Pomona Cal	Radiology

* Deceased

EXAMINATION FOR ENTRANCE INTO THE MEDICAL CORPS OF THE NAVY

An examination of candidates for appointment as Lieutenant (junior grade), in the Medical Corps of the Navy, will be held at all Naval Hospitals in the United States and at the Naval Medical School, Washington, D C, beginning May 16, 1938

Candidates for admission must be between the ages of 21 and 32 years at time of appointment, graduates of a Class "A" medical school, and have completed an internship of one year in a hospital accredited for interns by the American Medical Association and the American College of Surgeons

Those who are interested should write the Surgeon General, U S Navy, Bureau of Medicine and Surgery, Navy Department, Washington, D C, for further information in regard to the examination and the procedure to follow for them to appear before one of the Examining Boards

BOOKS RECEIVED

Books received are acknowledged under this heading, and such notice may be regarded as an acknowledgment of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits

DAS VENTRICULOGAMM (The Ventriculogram)
Acta Radiologica, Supplementum XXV
By ERIK LYSHOLM, Dozent für Medizin, Radiologie, BERTIL EBENIUS, und HANS SAHLSTEDT, Assistenten am Röntgeninstitut II—Teil, Die Seitenventrikel. A volume of 199 pages, with 284 illustrations. Published by P A Norstedt & Sons, Stockholm, Sweden, 1937. Price 15 Kronen

THE PRACTICE OF IONIZATION By J NEWTON DYSON, M R C S (Eng), L R C P (Lond), with a Foreword by ELKIN P CUMBERBATCH, M.A., B M., (Oxon), D R M E (Camb), F R C P. A volume of 178 pages, with 9 illustrations. Published by Henry Kimpton, London, England, 1936. Price \$1 50

SYNOPSIS OF DIGESTIVE DISEASES By JOHN L KANTOR, Ph D., M.D., Associate in Medicine, Columbia University, Gastroenterologist and Associate Roentgenologist, Montefiore Hospital for Chronic Diseases, New York. A volume of 302 pages, with 40

illustrations. Published by C V Mosby Co., St Louis, Mo., 1937. Price \$3 50

THE ROENTGENOLOGIST IN COURT By SAMUEL WRIGHT DONALDSON, A B., M D., F A C R., St Joseph's Mercy Hospital, Ann Arbor, Michigan. A volume of 230 pages. Published by Charles C Thomas, Springfield, Ill., 1937. Price \$4 00

SOME QUANTITATIVE ASPECTS OF THE BIOLOGICAL ACTION OF X- AND GAMMA RAYS By C M SCOTT, M D. Special Report Series No 223. A volume of 99 pages, with 21 illustrations. Medical Research Council

RADIATION THERAPY ITS USE IN THE TREATMENT OF BENIGN AND MALIGNANT CONDITIONS By IRA I KAPLAN, B Sc., M D., Clinical Professor of Surgery, New York University Medical College, Director, Radiation Therapy Department, Bellevue Hospital, New York, Director, Division of Cancer, Department Hospitals, City of New York, Director, New York City Cancer Institute, Associate Radiologist, Lenox Hill Hospital, New York. Editor (Therapeutic Section) "Year Book of Radiology". A volume of 558 pages, with 198 illustrations. Published by Oxford University Press, New York City. Price \$10 00

THE 1937 YEAR BOOK OF RADIOLOGY Radiologic Diagnosis. Edited by CHARLES A WATERS, M D., Associate in Roentgenology, Johns Hopkins University, Asst Visiting Roentgenologist, Johns Hopkins Hospital. Associate Editor, WHITMER B FIROR, M D., Asst in Roentgenology, Johns Hopkins University. Therapeutics, Edited by IRA I KAPLAN, B Sc., M D., Director, Division of Cancer, Dept of Hospitals, City of New York, Clinical Professor of Surgery, New York University Medical College, Director Radiation Therapy Dept., Bellevue Hospital, New York City, Director, New York City and Brooklyn Cancer Institutes, Associate Radiologist, Lenox Hill Hospital, New York City. A volume of 503 pages, with 550 illustrations. Published by The Year Book Publishers, Inc., Chicago, Ill., 1937. Price \$4 50

PRINCIPLES OF ROENTGENOLOGICAL INTERPRETATION By L R SANTE, M D., Professor of Radiology, St Louis University School of Medicine, Radiologist to St Louis City Hospital and St Mary's Hospital, St Louis. A volume of 340 pages, with 330 illustrations. Published by Edwards Brothers, Inc., Ann Arbor, Michigan, 1937. Price \$5 50

1047	Weber, Harry M	Rochester Minn	Roentgenology
1048	Weed, Walter A	Orlando, Fla	Radiology
1049	Weeks, Paul R	Denver, Colo	Radiology
1050	Weinberg, Tobias B	New York, N Y	Roentgenology
1051	Weirauch, Herbert V	Columbus, O	Diagnostic Roentgenology
1052	Weiskotten, W Otto	San Diego, Cal	Roentgenology
1053	Weitzner, Imre	New York, N Y	Radiology
1054	Weitzner, Samuel F	New York, N Y	Diagnostic Roentgenology
1055	Wentworth, A J	Mankato, Minn	Radiology
1056	Wescott, William C	Atlantic City, N J	Radiology
1057	West, James H	Cleveland O	Radiology
1058	West, Theodore S	Port Chester, N Y	Roentgenology
1059	Westing, Siegfried	Brooklyn, N Y	Diagnostic Roentgenology
1060	Wheatley, Frank E	Boston Mass	Radiology
1061	Wheatley, Louis F	New Haven Conn	Roentgenology
1062	Wheeler, Digby	Winnipeg, Man	Roentgenology
1063	Whelan, Charles	Boston Mass	Radiology
1064	Whitaker, Ben T	Boone, Ia	Roentgenology
1065	White, Clarence M	Beaumont, Tex	Diagnostic Roentgenology
1066	White, Stephen	New York, N Y	Diagnostic Roentgenology
1067	Whitehead, Ely L	Brooklyn, N Y	Radiology
1068	Whitehead, Lawther J	Richmond Va	Roentgenology
1069	Whitlock, Simon B	Norfolk Va	Roentgenology
1070	Widmann, B P	Philadelphia, Pa	Radiology
1071	Wigby, Palmer E	Dallas, Tex	Radiology
1072	Wilcox, Clark A	Wichita Falls, Tex.	Radiology
1073	Wilcox, Leslie F	Detroit, Mich	Radiology
1074	Williams, Albert E	Hines Ill	Therapeutic Radiology
1075	Williams, Arthur J	San Francisco, Cal.	Radiology
*1076	Williams, Francis H	Boston Mass	Radiology
1077	Williams, Lester J	Baton Rouge, La	Radiology
1078	Williams, P A	Hempstead, N Y	Roentgenology
1079	Willy, Ralph G	Chicago Ill	Roentgenology
1080	Winchell, A Vaughn	Philadelphia, Pa.	Therapeutic Radiology
1081	Wilson, Hugh M	New Haven Conn	Roentgenology
1082	Wilson, James E	Clarksburg W Va.	Diagnostic Roentgenology
1083	Wilson, John S	Monticello, Ark	Therapeutic Radiology
1084	Wilson, R. T	Austin Tex	Roentgenology
1085	Wilson, Stanley A	Salem, Mass	Roentgenology
1086	Wirth, John E	Seattle, Wash	Therapeutic Radiology
1087	Wissler, J E	Washington D C	Radiology
1088	Withers, Sanford M	Denver, Colo	Therapeutic Radiology
1089	Witwer, E R	Detroit, Mich.	Radiology
1090	Woodruff, Marston T	Philadelphia, Pa.	Roentgenology
1091	Woolford, Joseph S	Eureka Cal	Radiology
1092	Woolley, Ivan M	Portland Ore.	Roentgenology
1093	Wright, Cecil S	Indianapolis Ind.	Radiology
1094	Wright, Harold E	Baltimore Md	Roentgenology
1095	Wurster, Lloyd E	Williamsport, Pa	Roentgenology
1096	Wyatt, George M	Cleveland O	Roentgenology
1097	Young, Barton R	Philadelphia Pa	Radiology
1098	Young, James L R.	New York, N Y	Therapeutic Radiology
1099	Zeitlin, Nathan S	Chicago, Ill	Roentgenology
1100	Ziliak, A Lawrence	Bay City Mich	Roentgenology
1101	Zimmerman, Carl A. W	Cape Girardeau, Mo	Diagnostic Roentgenology
1102	Zink, Oscar C	St Louis, Mo	Radiology
1103	Zulick, J Donald	Philadelphia Pa	Roentgenology

* Deceased

The Board will hold two examinations during 1938, the first at the Mark Hopkins Hotel in San Francisco, June 10-12, and the second at the time and place of the meeting of one of the two national radiologic societies, depending on which society meets at the more convenient place. Those wishing to appear

for examination in San Francisco should have their applications on file by March 1.

For information, communicate with the Secretary, 102-110 Second Avenue, S W, Rochester, Minnesota.

B R Kirklin, M D
Secretary-Treasurer

ABSTRACTS OF CURRENT LITERATURE

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S RICHARD BEATTY, M D, of Madison, Wis	E T LEDDY, M D, of Rochester, Minn
J E HABBE, M D, of Milwaukee, Wis	ERNST A POHLE, M D, Ph D, of Madison, Wis
HANS W HEFKS, M D, of Milwaukee, Wis	CHARLES G SUTHERLAND, M B (Tor), of Rochester, Minn

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THE COLLAPSE THERAPY OF PULMONARY TUBERCULOSIS By JOHN ALEXANDER, M D, F A C S, Professor of Surgery, University of Michigan, Surgeon-in-Charge, Division of Thoracic Surgery, Department of Surgery, University of Michigan Hospital. A volume of 705 pages, with 367 illustrations. Published by Charles C Thomas, Springfield, Ill, 1937. Price \$15 00

BOOK REVIEWS

CARCINOMA OF THE FEMALE GENITAL ORGANS By M C MALINOWSKY and E QUATER. A volume of 255 pages, with 50 illustrations. Published by Bruce Humphries, Inc, Boston, Mass, 1936. Price \$5 00

This volume, translated from the Russian by A S Schwartzmann, while not exhaustive, contains a sufficiently thorough discussion of the problem of carcinoma of the female sexual sphere. Beginning with a chapter on the pathogenesis and etiology of tumors, the writers discuss all phases of the problem including pathology, clinical appearance, and treatment, and wind up with a brief word on carcinoma of the breast. The material is ably arranged and presents what is probably a consensus of the opinions of most writers on this subject.

The chapters on treatment are particularly good, giving an unbiased view of the places held by surgery and radiant energy. Methods of combining radium and x-ray are described and evaluated, and statistics are extensively quoted. The book is amply illustrated.

GRUNDZÜGE DER RÖNTGENPHYSIK (Fundamentals of Roentgen Physics). Eine Einführung in die Gesetze der Röntgenstrahlen zur Verwendung in Physik, Kristallographie, Medizin, und Technik. By Dr PHIL FRITZ REGLER. A volume of 467 pages, with 339 illustrations. Published by Urban & Schwarzenberg, Berlin, Germany, 1937. Price RM 21.

The author, who is an assistant professor in the "Technische Hochschule" in Vienna, has

prepared this book to familiarize the reader with the fundamental laws governing roentgen rays as they apply to physics, crystal analysis, medicine, and industry.

Following a brief introduction regarding the production and wave length of roentgen rays their nature is explained in detail. Ample space is devoted to the discussion of the x-ray spectrum, the absorption and ionization by roentgen rays, their photochemical and biological effects. Under the heading "Ionization" the reader finds data on the international "r" and methods of determining the output of x-ray apparatus. The Geiger counter is briefly described. Brief but practical data on protection against radiation are also supplied. Those interested in radiographic technic will welcome the chapter dealing with the theoretical principles involved in producing and evaluating the roentgenogram. This includes the principles of stereoscopy, cinematography, and testing of screens. The theories of roentgen spectroscopy and crystal analysis by means of roentgen rays are clearly related and the methods of Laue, Debye-Scherrer as well as the rotating crystal method have been included.

The relation between tube potential and half value layer, the determination of the depth dose percentage and methods for measuring high voltage are also outlined. A discussion of diffraction of electrons on crystals, scattering of roentgen rays and electrons in liquids and gases, and a description of roentgen apparatus and tubes conclude the text. An appendix contains some tables with useful data on the wave length of characteristic radiation and lattice constants.

Because the book is meant for a large group of readers the author has attempted not to give preference to the interests of one single science. This accounts for the fact that the medical reader would like, perhaps, additional data and more detail in those chapters which are of specific interest to him. However, the book contains a wealth of material, and because difficult mathematical formulæ have been omitted, without subtracting from the accuracy of the presentation, it is recommended as a good introduction into the fundamentals of x-ray physics.

This is a report of a typical case of hyperparathyroidism in which surgical excision of an adenoma of the left lower parathyroid gland resulted in marked clinical improvement

Bio assay of the gland revealed approximately 105 units of hormone per gram

Search of the literature revealed no previous instance in which direct analysis was made of the hormone content of such an adenoma

CHARLES G SUTHERLAND, M B (Tor)

THE KIDNEY

Small Calculus in the Kidney Pelvis Localized by the Intravenous Injection of a Small Quantity of Ténèbryl H Bécère Bull et Mém Soc Radiol Méd de France, January 1937, 25, 11 12

A small opaque calculus in the region of the right kidney was definitely localized by the injection of 20 cc of 30 per cent Ténèbryl which gave a shadow of relatively little density After 15 minutes the stone was hidden by the dye, but after 35 minutes, lessened concentration of the dye permitted its visualization in the lower pole of the pelvis

S RICHARD BEATTY M D

Echinococcus Cyst of the Kidney Joseph Tenenbaum Jour Am Med Assn May 15 1937, 108, 1704, 1705

Hydatid disease involving the kidney is rare in this country Approximately thirty cases have been reported in the American literature Hydatid disease represents the larval or cystic stage of the *Taenia echinococcus* which in the mature stage is found in the small intestine of the dog wolf, cat, and other carnivora In common with cattle, sheep horses, and other herbivora, man shares the function of intermediary host through ingestion of parasitic ova passed on with the feces from an infested primary host (commonly the dog) The larva liberated in the process of digestion is carried through the portal venous system to the liver (the most common location of hydatid cyst) thence less commonly to the lungs and, if not arrested before it reaches the left ventricle it may be swept through the circulation into any other part of the body including the cortex of the kidney Echinococcus cyst in the kidney is found in about 2 per cent of the cases of hydatid disease

It takes approximately fifteen to twenty years for the development of a full sized echinococcus cyst and as long as there is no communication with the pelvis (closed cyst) there are no early symptoms except such as may be caused later through pressure displacement, and destruction of the kidney substance associated with hydronephrosis In time especially in the presence of infection, the tissues of the hydronephrotic pelvis adjacent to the sac may yield to pressure, establishing free communication for spontaneous evacuation of the cystic

contents (spontaneous cure) More often after spilling some of its contents the communicating rent may become sealed and the sac refilled with daughter cysts (fractional evacuation) This process may be repeated from time to time, accompanied by renal colic due to passage of the daughter cysts through the ureters, and occasionally hematuria There are two other eventualities of cyst involution one caused by the slow leakage and absorption of the echinococcus fluid, with consecutive degeneration and calcification of the cyst (a process similar to autonephrectomy in renal tuberculosis), or the cyst may rupture externally, spilling its contents into the perirenal space and peritoneal sac (hydatid peritonitis) There is also danger of metastatic secondary echinococcosis due to a rupture of a fertile simple cyst into the heart or venous system

Plain roentgenograms of the genito urinary tract may or may not show the presence of a large mass in the kidney region, pyelography rarely fails to demonstrate some degree of hydronephrosis compression or displacement, irregularity or a moth-eaten appearance of one or more calices, and in the colicky type some degree of dilatation of the ureter

CHARLES G SUTHERLAND, M B (Tor)

THE KNEE JOINT

Primary Hematogenous Osteitis of the Patella F L Flack Jour Am Med Assn June 26, 1937, 108, 2199

Primary spontaneous hematogenous osteitis of the patella, according to the reported cases, is rare The diagnosis of this condition is not often made early enough to prevent marked destruction of the patella and extension of the lesion Records of about 40 cases were found in the literature

The author reported a case in a female, aged 20, with a history of gradually increasing pain over a period of eight weeks There was no history of trauma or local infection X-ray examination showed marked absorption and osteitis of the patella with multiple sequestra An incision was made over the patella, and a large pocket of pus was evacuated Microscopic examination and cultures showed *Staphylococcus aureus* While no history was obtainable, a metastatic infection from the throat was suspected as the etiologic factor

CHARLES G SUTHERLAND, M B (Tor)

THE LUNGS

Cancer of the Lung in the Hospitals of Brussels M Herlant Bruxelles Médical March 28, 1937, 800-819

It is the belief of the author that the actual incidence of pulmonary cancer is increasing In one of Brussels, two larger hospitals, in 1924, the percentage of pulmonary cancers found was 2.2 per cent of all cancers In 1935, 14.5 per cent of all cancers were pulmonary

HEART AND VASCULAR SYSTEM

A Roentgenological Study of the Heart Size in Athletes Hugo Roesler Am Jour Roentgenol and Rad Ther, December 1936, 36, 849-853

The author discusses the differing opinions of various investigators as to the influence of strenuous athletics requiring prolonged exertion on heart size and heart muscle hypertrophy. Serial or single ortho-diaphractic studies on four individuals all giving a history of some years of athletic activities lead to the belief that as a result of such physical activities there may develop a slight but significant enlargement to be followed by measurable decrease in heart size shortly after such exertions are discontinued.

J E HABBE, M D

Directed Roentgenography of the Thorax (The Cardiocairograph) I Seth Hirsch and Myron Schwarzschild Am Jour Roentgenol and Rad Ther, January, 1937, 37, 13-20

This refers to an exposure of the chest at a predetermined phase of the cardiac cycle, and is accomplished by the synchronization of the exposure with a selected phase of the circulatory phenomenon, namely, the action current impulse. The desirable instant is the end phase of diastole, and by the use of an apparatus which is very thoroughly described the exposure is made by the R wave of the electrocardiogram, and thus without the use of any time delay. If it is desired to make the exposure at systole it can be simply arranged so. Thus the heart in systole and diastole can be compared and films at a later date taken in the same phase for comparison. This method has proven that an exposure lasting through several cardiac cycles does not show the heart in maximum diastole. Kymographic studies can also be timed for correct phase by the same apparatus.

This apparatus, by means of which for the first time the exposure can be made at a predetermined phase of the cardiac cycle, was invented and constructed by the authors.

S M ATKINS, M D

Dissecting Aneurysm of the Aorta T E McGeachy and J E Paulin Jour Am Med Assn, May 15 1937, 108, 1690-1698

Of almost 500 cases dealing with rupture of the aorta reported in the literature in only nine has a correct antemortem diagnosis been made. Dissecting aneurysm of the aorta is an incomplete rupture of the aortic wall wherein the escaping fluid separates the layers of the arterial wall to a variable extent. There is usually a terminal rupture at some distant point either externally or into the original blood channel. Rarely, spontaneous fibrosis and healing occur without a second rupture. It is most common between the ages of 40 and 70 years. Males are affected twice as frequently as females. It is found approximately once in 500 autopsies. There are two main causative factors: a defective aortic wall, usually a degenerative change in

the media as a result of sclerosis of the vasa vasorum and an abnormal hydrostatic pressure in the aorta.

The onset is sudden during exertion with agonizing tearing pain usually in the anterior portion of the chest which is so severe that shock immediately follows. The pain more often radiates to the back in either the thoracic or the lumbar region.

The roentgenographic features are a deformity of the supercardiac shadow, which may or may not pulsate under the fluoroscope, an arcuate excrescence arising from any portion of the thoracic aorta at times a shadow may be seen along an aortic branch and this is the most pathognomonic of all x-ray appearances. There is at times displacement of the trachea and esophagus and at times a non-fatal leakage may be evident as a pleural effusion, usually left-sided or as a mediastinal infiltration. Cardiac hypertrophy is nearly always present.

CHARLES G SUTHERLAND M B (Tor)

HODGKIN'S DISEASE

Hodgkin's Disease and Allied Conditions of Bone Richard Dresser and Jack Spencer Am Jour Roentgenol and Rad Ther, December 1936, 36, 809-815

In a recent five year period 149 cases of Hodgkin's disease were examined with particular attention to the osseous system for evidence of bone lesions. There were 16 cases showing bone changes, an incidence therefore of 10.7 per cent. Subsequent to this series there were 46 more cases found with bone changes in Hodgkin's disease. The pathologist classified most of the bony lesions as belonging to the Hodgkin's group, a small percentage as reticulum cell sarcoma and a very few as lymphosarcoma. The majority of the cases were in the third or fourth decades of life.

The bones most commonly involved were spine (usually lumbar), 24 per cent, pelvis, 19 per cent, ribs, 9 per cent, sternum, 7.5 per cent. The x-ray appearance simulates metastatic malignancy or (less often) Ewing's tumor, osteogenic sarcoma or bone cyst. The picture is not characteristic.

The bone involvement was an early one in 25 per cent of the cases wherein it was found. However, a primary involvement of the bones without involvement of lymph nodes, spleen or liver was not found, the bone involvement being either metastatic via the blood stream or by direct extension from diseased glands.

While relief of pain by roentgen therapy is often striking the x-ray appearance of the lesions after treatment is often stationary. High voltage and daily doses of from 200 to 300 r are recommended.

J E HABBE M D

HYPERPARATHYROIDISM

Bio-assay of a Parathyroid Adenoma in a Case of Generalized Osteitis Fibrosa. Sylvan E Moolten, Francis M Clarke and Henry Haywood Jour Am Med Assn Jan 9 1937, 108, 111-112

sion and deep palpation were not used, the author believes that filling of the stomach with a rather large amount of barium was probably the cause for this accident. The patient died.

A case of perforation of the bladder probably caused by a very difficult cystoscopic examination with contrast material outside the bladder on the cystogram shows the danger of injection of such substances after a difficult cystoscopy. The outcome was fatal.

Injury to the kidneys by ureter catheters is not a rare occurrence. In the author's case the catheter apparently perforated a calyx and kidney substance. The skodan was seen between the kidney proper and its capsule. There was no untoward reaction from this accident.

HANS W. HEFKE, M.D.

PITRESSIN

Use of Pitressin. A. Jutras and A. Cantero. *Jour de Radiol. et d'Electrol.*, August 1936, 20, 443-445. (Reprinted by permission from *British Med. Jour.*, Dec. 12 1936, p. 98 of *Epitome of Current Medical Literature*.)

The authors advise the use of pitressin, which is a non-oxytocic extract of the anterior lobe of the pituitary, in all cases of abdominal radiography in which the presence of gases may prove disturbing. Pitressin causes contraction of the smooth muscular fibers and thus helps to expel the intestinal gases. Pitressin is contra-indicated in cases of intestinal obstruction and in cases suffering from cardiac, vascular, or renal disease in view of the temporary increase of the blood pressure it usually produces. The medicament is given in doses of 1 c.c. intramuscularly. The authors usually give a saline enema before cholecystography and a plain water enema in intestinal radiography (for examination of the relief of the mucous membrane) prior to injection of pitressin. The radiographs are taken from one to three hours after the injection.

THE PROSTATE

Effect of Roentgen Therapy on Hypertrophy of the Prostate. G. H. Schneider. *Strahlentherapie* 1937, 59, 346.

The author relates his experience with roentgen therapy in non-malignant hypertrophy of the prostate. He uses five fields of 10 × 15 cm. size and administers from 360 to 500 r per area in order to have 90 per cent of a skin erythema dose effective in the gland. A caliper is shown which permits the exact determination of the distance between skin surface and prostate. An analysis of 24 cases treated by him showed encouraging results.

ERNST A. POHLE, M.D., Ph.D.

The Treatment of Prostatic Carcinoma. Benjamin S. Barringer. *Am. Jour. Roentgenol. and Rad. Ther.*, January 1937, 37, 49-52.

The most common origin of carcinoma is in the pos-

terior lobe, especially when the lesion is large enough for diagnosis, and here aspiration biopsy will be dependable in 80 per cent of the cases. Cystoscopy with examination of section of the bladder neck can also be done. Surgical removal is difficult and the results not very satisfactory, and thus interstitial radon needles and external radiation combined offer a better outlook.

S. M. ATKINS, M.D.

RADIATION INJURIES

Roentgen Injuries Following Therapeutic Irradiation. J. Körbler. *Strahlentherapie*, 1937, 59, 146.

The author reports six cases of late roentgen injuries and discusses the precautions which should be observed in their prevention. Even so-called safe doses may lead to late reactions, especially if some secondary agent (ultra violet light, medication, or chronic irritation) affects the irradiated skin.

ERNST A. POHLE, M.D., Ph.D.

Findings in the Death of a Radiologist. M. Roques. *Bull. et Mém. Soc. Radiol. Méd. de France*, January, 1937, 25, 95-98.

The clinical laboratory, and postmortem findings in the case of a radiological technician who was exposed to considerable roentgen radiation for ten years are given. The symptoms and clinical findings lead to a diagnosis of appendicitis, and laparotomy was performed. A trace of albumin was found in the urine. The blood studies showed 3,900,000 red cells, 19,700 white cells, polymorphonuclear leukocytes 87 per cent, small mononuclears 4 per cent, large mononuclears, 5 per cent, and lymphocytes 4 per cent. The peritoneal contents were normal at operation. The patient post-operatively suffered crises of abdominal pain and died in a week.

At postmortem the chief findings included a hazelnut-sized hemorrhage in the left frontal region, sanguineous peritoneal fluid with hemorrhage in the left subdiaphragmatic region centering in the pancreas, a small spleen with several milary infarcts, recent infarct in the right kidney.

The author believes death primarily was caused by hemorrhage in association with a toxic anemia due to x-ray. He discusses the effects of irradiation on the blood-forming elements.

S. RICHARD BEATTY, M.D.

A Severe Roentgen Combination Injury. V. Wucherpfennig. *Strahlentherapie* 1937, 58, 155.

The author relates the history of two boys who were epilated in August 1928 because of favus. As treatment 475 r were applied over five fields with 84 kv, no filter at 25 cm. F.S.D. Three weeks after the treatment both patients showed a roentgen reaction of the third or fourth degree over the scalp. Skin changes visible in the upper cheeks, eyelids, and conjunctiva were

In another hospital, of 446 cancer autopsies, pulmonary cancer was present in 6 per cent, in 1924 but in the year 1935 the incidence was 13 per cent.

Of a total of 103 cases of pulmonary carcinoma, 84 were men 19 were women. The major incidence occurred in the sixth decade, the youngest victim in this series being 28 the oldest 77.

The etiologic factors are discussed in some detail, no specific cause can be determined.

The author discusses the pathologic anatomy of pulmonary tumors, their metastases and the secondary pathology at length. The article is to be continued in another issue.

S RICHARD BEATTY M D

Thrombosis of the Pulmonary Artery G. Liebmeyer München med Wchnschr July 16, 1937 84, 1131 1132

This is a case report of a patient with thrombosis of the pulmonary artery and other cardiac disease. The author thinks the diagnosis can be made clinically on the basis of a cyanosis which has not been present since childhood of disproportion between the deep cyanosis and the slight dyspnea and of the finding of greatly increased and sharply marked out vascular shadows in the roentgenograms of the pulmonary hilus.

L G JACOBS M D

The Roentgenologic Appearance of Bulbous Emphysema in Subjects with Cervical Ribs Filoreto d'Agostino Archivio di Radiologia 1936 12, Nos 3-4 185-189

This is a case report of a patient followed for three years, who had bulbous emphysema in the left apex. The author illustrates the lesion by serial roentgenograms to show a relationship between it and cervical ribs.

E T LEDDA M D

Recurrent Idiopathic Spontaneous Pneumothorax Leslie K. Sycamore. Am Jour Roentgenol and Rad Ther, December 1936 36, 844-848

A case is reported of a male 30 years of age who within a period of three years suffered five attacks of spontaneous pneumothorax involving the right chest. The causative factor an emphysematous bleb was demonstrable at several of the roentgen examinations. After the fourth recurrence it was thought advisable to excise the bleb. This was done the microscopic appearances indicating emphysematous bleb rather than congenital cyst. The patient has since remained free of recurrence.

J E HASSE M D

Changes in Tumors of the Bronchus Following Radiation Therapy as Demonstrated in the Bronchogram A. Beutel and F. Strand Strahlentherapie 1937 59, 497

The authors studied the changes in the chest roentgenogram with and without lipiodol injection in patients who had been treated for carcinoma of the bronchus by roentgen rays. The response to the treatment manifested itself in the chest film in a slow disappearance of the density produced by the tumor followed by a shrinking process corresponding to an induration. Following injection of lipiodol the filling defects seen in the bronchus preceding the treatment become smaller the irregular edges appear more smooth, and some of the obstructed bronchi become patent. If metastatic lymph glands are present and are reduced under radiation therapy the encroachment on the bronchi disappears and normal contours are restored. The induration of the lung following shrinkage of the tumor may cause obliteration of some of the bronchi and lead later to the development of bronchiectasis.

ERNST A. POHLE M D Ph D

Cancer of the Lung Editorial Jour Am Med Assn, May 15 1937, 108, 1716 1717

The incidence of cancer of the lung as cited in recent statistical reports varies between 5 and 10 per cent of all cancers. Among the contributing factors to this unmistakably steady increase the injurious effects of tobacco smoking exhaust gases from automobiles, tar on roads and the influenza epidemic of 1918-1919 have been suggested. None of these can be accepted as definitely causative. The disease is preponderantly more common in males than in females about two thirds of all cases occur between the ages of 40 and 60. A persistent cough hemoptysis and thoracic pain of a severe and continuous type in a man past the age of 40 are highly suggestive of cancer. The earliest manifestations may be those of metastasis away from the thoracic cage. Bronchopulmonary cancer displays a tendency to give rise to metastases to the liver, bones, spleen, pancreas and with a characteristic frequency to the suprarenals and the brain. X-ray examination of the chest alone is capable of rendering a correct diagnosis of carcinoma in not less than two-thirds of all cases. Bronchoscopic examination in the hands of an expert is valuable not only because it can visualize the tumor within the main bronchus but even more so because of the possibility of obtaining a biopsy specimen. The future of therapy rests largely on the success of lobectomies and occasional pneumonectomies.

CHARLES G. SUTHERLAND M B (Tor)

PEPTIC ULCER

Perforations (Stomach Urinary Bladder Kidney) R. Janker Röntgenpraxis November 1936 8, 51

Perforation of ulcers during or shortly after roentgen examination has been reported about fifty times in the literature. Because of the comparative rarity of this occurrence a case of perforation of a gastric ulcer during roentgen examination is described. The barium was seen outside the stomach on the second film and free air was noted under the diaphragm. Because compres-

sion and deep palpation were not used, the author believes that filling of the stomach with a rather large amount of barium was probably the cause for this accident. The patient died.

A case of perforation of the bladder probably caused by a very difficult cystoscopic examination with contrast material outside the bladder on the cystogram shows the danger of injection of such substances after a difficult cystoscopy. The outcome was fatal.

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ERNST A. POHLE, M.D., Ph.D.

RADIUM

Prolonged Results in Some Cases Treated with Radium. M. T. Nogier. Bull. et Mém. Soc. Radiol. Méd. de France, January 1937, 25, 87-91.

The author presents three cases of cancer of the cervix alive and well fourteen years, seven years, six months, and five years, two months, respectively, following radium therapy, two cases of cancer of the tongue free of disease for six years, six months, and three years, five months, respectively, and a case of sublingual epithelioma now well for five years, three months. The case histories and technic of employment of radium are given.

S. RICHARD BEATTY, M.D.

The Application of "Weak Radium Therapy" in Dermatology. S. R. Brünauer. Strahlentherapie, 1937, 58, 83.

The term "weak radium therapy" comprises according to the author, the use of radium emanation taken in water *per os*, in bath or inhalations and also applications of radio active ointments. He describes a 9x12 sq. cm. flexible radium applicator containing 1 mg. radium bromide. It is so constructed as to permit the use of alpha, beta, and gamma rays. It may be applied for 12 hours in one sitting from three to six times, followed by an interval of from 10 to 14 days. The treatment seemed to be effective in eczema, psoriasis, lichen ruber planus, and papillomatosis of the skin in the face. The radon ointment was of benefit in pruritus, hyperkeratosis, and eczema between the toes.

ERNST A. POHLE, M.D., Ph.D.

Results of Treatment with Small Doses of Radium Emanation. E. Uhlmann. Strahlentherapie, 1937, 58, 664.

The author has seen good results in the treatment of roentgen ulcers by roentgen emanation. He has had opportunity to observe 60 cases during the last seven years. Radium ointment is used which contains from 50 to 100 E.S.E. per gram of vaseline. A dressing is applied and the emanation left, usually for eight hours. The treatment may be repeated at intervals of seven days. In patients whose skin is sensitive to ointments it is advisable to use moist dressings, preferably 2 per cent boric acid solution. Photographs of a roentgen ulcer before and after treatment in a patient with diabetes are shown in the article.

ERNST A. POHLE, M.D., Ph.D.

THE SPINE

Spondylolisthesis with Regional Disturbance of Calcium Metabolism. H. Tiller and Bréchet. Bull. et Mém. Soc. Radiol. Méd. de France, February 1937, 25, 138-141.

In conjunction with an old traumatic spondylolisthesis with marked variation in the amount of calcium in the vertebrae and calcification in the ilio-lumbar and other ligaments, films of the abdomen demonstrated a calcified plaque at the site of an appendectomy scar in one of the authors' cases. They hypothesize a regional disturbance in calcium metabolism subsequent to the injury.

S. RICHARD BEATTY, M.D.

Vertebral Epiphysitis and Pott's Disease. M. Chasard. Bull. et Mém. Soc. Radiol. Méd. de France, January 1937, 25, 81-83.

Vertebral epiphysitis in adolescents is rather frequent but is not always recognized in the less severe cases. The involvement of multiple vertebrae and the conservation of the intervertebral disks usually makes confusion with Pott's disease unlikely. Occasionally however, the vertebral bodies show irregularities, deformities, or actual loss of substance which simulate tuberculous lesions and rarely is there localized narrowing of the intervertebral space. The absence of the fusiform abscess shadow, the practically constant involvement of multiple vertebrae and the tendency to rapid recalcification and hyper-calcification will serve to distinguish these lesions from those of Pott's disease.

S. RICHARD BEATTY, M.D.

Symptomatology and Therapy of Metastatic Carcinoma in the Spine. O. Deutschberger. Strahlentherapie, 1937, 58, 684.

The author recommends 2000 r effective in the affected vertebra and applied during a period of from three to four weeks in the treatment of metastatic carcinoma of the spine. Relief from pain is seen in the majority of cases and in a small percentage recalcification occurs after a period of from three to four months. While some lesions may remain healed for a year and one half, recurrences usually do occur.

ERNST A. POHLE, M.D., Ph.D.

Multiple Tumors within the Spinal Canal. John D. Camp. Am. Jour. Roentgenol. and Rad. Ther., December 1936, 36, 775-781.

For completely obstructing lesions of the spinal canal the use of 2 c.c. of lipiodol as originally recommended by Forestier in 1922 may be sufficient, but when there are multiple tumors which only partially obstruct the canal space the author has found it necessary to inject 5 c.c. of the opaque oil and thereafter to observe the movements of the oil on a tilting roentgenoscopic table.

with the patient in supine, prone, oblique and lateral positions. While the large majority of spinal cord tumors are single, in a recent series of 72 cases 4 per cent were identified as multiple by the writer, using the above-described technic. Five cases of multiple cord tumors, with or without co-existing prolapse of the intervertebral disks, are reported.

J E HABBE, M D

The Azygos Lobe and Congenital Costo vertebral Malformations. M J Jalet. *Bull et Mém Soc Radiol Méd de France* February, 1937 25, 141-143.

The author calls attention to the frequency with which abnormalities of the cervical spine accompany the presence of an azygos lobe. These abnormalities include cervico dorsal scoliosis, hypertrophy of the transverse processes of the seventh cervical vertebra, cervical ribs, spina bifida occulta, hemivertebra, and other anomalies of maldevelopment or fusion of the cervical vertebrae.

S RICHARD BEATTY, M D

The Roentgenographic Demonstration of Rupture of the Intervertebral Disk into the Spinal Canal after the Injection of Lipiodol. Aubrey O Hampton and J Maurice Robinson. *Am Jour Roentgenol and Rad Ther*, December 1936 36, 782-803.

The authors report the technic of examination and the findings in cases of unilateral or bilateral rupture of the intervertebral disks with protrusion of the posterior portion of the disk into the spinal canal space. These cases clinically did not have symptoms of cord tumor but were clinically classified as "low back strain," "sciatica," or "sacro-iliac disease" cases. The accuracy of the method is indicated by the fact that 30 out of 31 cases of intervertebral disk ruptures operated upon in the past three years at the Massachusetts General Hospital were correctly diagnosed prior to surgery.

Of 39 lesions in the lumbar region 92 per cent were located at L4 or L5 (that is, below the fourth or below the fifth lumbar body), with L4 being twice as common as L5. Eight of these cases were "bilateral," that is the rupture extended across the midline producing bilateral involvement. A history of trauma, often relatively mild, was obtained in 60 per cent of the series.

Disregarding narrowing changes of the disk at L5 which are regularly difficult to evaluate, a decrease in width of the space of L4 disk was of localizing value in 25 per cent of all lumbar cases and in 33 per cent of L4 ruptures. (While the narrowing is suggestive of rupture it does not, of course, indicate whether the herniation is posterior or not, nor is it of significance in the prognosis.) Other changes of significance, especially if associated with the above, are loss of the usual lordotic curve and sciatic scoliosis.

The majority of the cases in this series varied from 25 to 45 years of age.

Previously the examination was made after injection of 2 c.c. of lipiodol into the cisterna magna but now the routine procedure is to inject 5 c.c. into the lumbar

spinal canal. The examination may be made any time from immediately after injection up to several days or even several weeks later according to the convenience of the operator and condition of the patient. The examination is done on a tilting roentgenoscopic table, preferably with quick change-over switch to permit the obtaining of focal study roentgenograms promptly upon discovery of abnormalities in distribution of the oil while changing the position of the patient to shift the oil up or down the spinal canal space.

The determination of the spinal fluid protein by spinal puncture is done to show the indication for lipiodol study. The protein test was elevated definitely (over 50 mg per cent) in 32 of the 39 cases, and slightly (40 to 50 mg) in four more. The total protein content, however, decreases rapidly with the distance above the lesion, hence the withdrawal of spinal fluid should be from the same level as the lesion is suspected to occupy. The writers have encountered no severe reactions even with this larger injection of the oil.

By a large number of excellent artists' drawings and reproductions of roentgenograms, the authors illustrate the normal anatomy of the spinal canal and its contents, and the x-ray and operative findings in posterior herniation of the intervertebral disk, both unilateral and bilateral types. They conclude that by this improved technic, and the correlation of the clinical laboratory, and x-ray findings, a correct pre-operative diagnosis should be possible in nearly every case presenting this condition.

J E HABBE M D

THE TEETH

Roentgen Therapy of Paradentitis. Staunig and Neugebauer. *Strahlentherapie*, 1937, 59, 528.

The authors relate their experience with the use of roentgen rays in the treatment of paradentitis. Technic: three fields were used, one anterior and two lateral areas. The radiosensitive organs like eye, parotid and thyroid must be carefully protected. Each field receives one dose of 200 r at 140 kv and 0.3 mm Zn + 2 mm Al, the interval between these three treatments is seven days. In the authors' experience the results were most satisfactory.

ERNST A. POHLE, M D, Ph D

Evaluation of Dental Roentgen Findings in Relation to Focal Infection and Systemic Disease. Herman A. Osgood. *Am Jour Roentgenol and Rad Ther*, December 1936, 36, 751-756.

The use of a "slow" film and a fine focus tube with careful angulation of the incident ray are essentials to accurate diagnosis of peri-dental disease. The first pathologic change demonstrable on the x-ray film is the widening of the black line of the pericementum at the apex, indicating thickening of this structure due to inflammatory congestion. The cause may be traumatic occlusion, inflamed or irritated pulp, or the first stage of an abscess formation. If the first roentgeno-

suspicious of a chemical reaction and appeared to be due to the application of chrysarobin applied since the treatment. The lesions in one patient healed eventually with complete epilation after four months, while the other required treatment over a two-year period. The court exonerated the clinic on the basis of the explanation of a combined injury.

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THE SPINE

Spondylolisthesis with Regional Disturbance of Calcium Metabolism. H. Tullier and Bréchet. *Bull. et Mém. Soc. Radiol. Méd. de France*, February, 1937, 25, 138-141.

In conjunction with an old traumatic spondylolisthesis with marked variation in the amount of calcium in the vertebrae and calcification in the ilio-lumbar and other ligaments, films of the abdomen demonstrated a calcified plaque at the site of an appendectomy scar in one of the authors' cases. They hypothesize a regional disturbance in calcium metabolism subsequent to the injury.

S. RICHARD BEATTY, M.D.

Vertebral Epiphysitis and Pott's Disease. M. Chasard. *Bull. et Mém. Soc. Radiol. Méd. de France*, January, 1937, 25, 81-83.

Vertebral epiphysitis in adolescents is rather frequent but is not always recognized in the less severe cases. The involvement of multiple vertebrae and the conservation of the intervertebral disks usually makes confusion with Pott's disease unlikely. Occasionally, however, the vertebral bodies show irregularities, deformities, or actual loss of substance which simulate tuberculous lesions and rarely is there localized narrowing of the intervertebral space. The absence of the fusiform abscess shadow, the practically constant involvement of multiple vertebrae and the tendency to rapid recalcification and hyper-calcification will serve to distinguish these lesions from those of Pott's disease.

S. RICHARD BEATTY, M.D.

Symptomatology and Therapy of Metastatic Carcinoma in the Spine. O. Deutschberger. *Strahlentherapie*, 1937, 58, 684.

The author recommends 2,000 r. effective in the affected vertebra and applied during a period of from three to four weeks in the treatment of metastatic carcinoma of the spine. Relief from pain is seen in the majority of cases and in a small percentage recalcification occurs after a period of from three to four months. While some lesions may remain healed for a year and one half recurrences usually do occur.

ERNST A. POHLE, M.D., Ph.D.

Multiple Tumors within the Spinal Canal. John D. Camp. *Am. Jour. Roentgenol. and Rad. Ther.* December, 1936, 36, 775-781.

For completely obstructing lesions of the spinal canal the use of 2 cc. of lipiodol as originally recommended by Forestier in 1922 may be sufficient but when there are multiple tumors which only partially obstruct the canal space the author has found it necessary to inject 5 cc. of the opaque oil and thereafter to observe the movements of the oil on a tilting roentgenoscopic table.

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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gram shows considerable destruction of the pericementum over the apex, the prognosis is poor even though there may be little destruction of the adjacent cancellous bone

Scar bone is not necessarily the result of infection, it may occur in chemical irritation from root canal treatment or by injury (traumatic occlusion). Scar bone seen occasionally without close relation to the peridental tissues is of no significance except there be pressure irritation on a nerve.

If a pulpless tooth shows normal pericemental attachments and investing structures, it may not be a dead tooth and need not be extracted. On the other hand, a canal filling which shows a space between the gutta percha and the canal walls is worthless.

Removal of infected teeth showing granuloma or acute abscess is more apt to be effective in relieving systemic symptoms than removal of teeth in cases in which chronic abscess with scar bone formation has taken place.

J E HABBE, M D

Roentgen Diagnosis and Treatment with X-rays in Dental Conditions J Heiss München med Wchnschr, March 26, 1937, 84, 501-506

Since the tooth is an integral part of the living body, its care should depend on co-operation between dentists and doctors. The progress of dentistry has in a large measure been tied up to the development of x-ray diagnosis. The author gives a rather elementary but complete and understandable discussion of the x-ray anatomy of the normal tooth, followed by a discussion of the diagnosis of the various diseases of the teeth and jaws. Much emphasis is placed on the ordinary diagnostic traps, such as confusion of normal foramina with abscesses. The use of contrast media in the diagnosis of cysts is mentioned, the discussion includes cysts, infections, and some tumors of the jaws.

The author, discussing the use of roentgen therapy in dental conditions, states that this is decidedly not the field of the dentist, but of the medical radiologist. He finds irradiation practically without value in dental abscess and pyorrhea. Good results are obtained in actinomycosis of the jaw, and he has seen cases rendered symptom-free for six years. He considers our knowledge of the results of radiation of malignant tumors of the

jaw incomplete. Post-operative radiation of adamantinoma and epulis has given good results in his hands. He has also obtained good results in osteomyelitis, even if exacerbation should occur, he finds the course of the disease shortened. He also advocates treating soft tissue inflammations and trigeminal neuralgia.

L G JACOBS M D

TUBERCULOSIS, PULMONARY

The Incidence of Tuberculous Infection in American College Students Esmond R. Long and Florence B Seibert Jour Am Med Assn May 22 1937 108, 1761-1765

The sharp upward trend of the tuberculosis mortality curve from the low level of pre-puberty years to the high level of early adult life coincides with the age period of the college student. The majority of cases of pulmonary tuberculosis still come to medical attention for the first time when already in an advanced state.

A survey of tuberculosis hospitals and sanatoriums in the United States recorded 13.1 per cent of 66,861 patients as admitted in the minimal stage, and 29.7 and 57.2 per cent, respectively as moderately and far advanced.

The reason for this general delayed diagnosis of tuberculosis lies in the fact that its symptoms are trivial in the early stage and commonly not serious enough to urge the patient to seek medical attention. Myers and Wulff observed the chests of the same individuals over years and saw lesions appear and progress to massive proportions without the individual suffering a single symptom. Diehl found 15 cases of active tuberculosis in 2,500 students. 'Had we depended on physical examination and history alone for ordering x-rays of the chest 10 of the 15 cases would have been missed.'

At the University of Wisconsin Stuehm recorded an increase of 430 per cent above a previous 14 year average after the institution of a definite program for discovering cases of tuberculosis in the student body.

The tabulated results of standardized examinations at 20 colleges showed a geographic variation of incidence, probably a reflection of the level of tuberculous infection in the community concerned.

CHARLES G SUTHERLAND M B (Tor)

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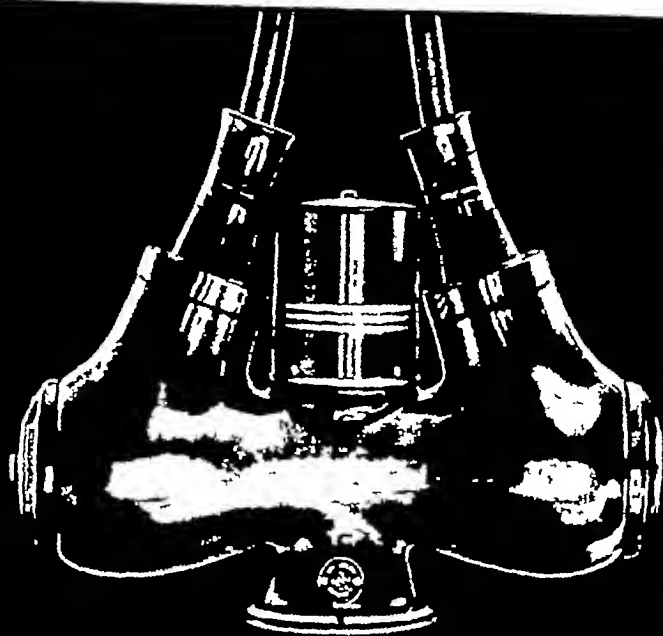
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